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(54) **SURGICAL MICROSCOPIC SYSTEM**

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(58) **Field of Search** 359/368–390; 600/122–132

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(57) **ABSTRACT**

Provided is a surgical observational system capable of effectively displaying, in the field of an operating microscope, a real-time image obtained by means of an ultrasonic probe, for example, and a slice image obtained by a preoperative diagnosis on the location of the distal end portion of the probe or a three-dimensional image of an affected region, in association with an actual observational image obtained by means of the microscope. The surgical operation observational system is provided with two monitors in the operating microscope for the observation of the affected region to be operated. Images on the two monitors are alternatively superposed on the optical path of the operating microscope.

19 Claims, 50 Drawing Sheets

FIG. 1

30
1
3
38
POSITION DETECTOR
31
37
ULTRASONIC OBSERVER
39
32
35
COMPUTING UNIT
INPUT MEANS
P
MONITOR
40
MIXER
33
LIQUID CRYSTAL DRIVER
34
36
FOOT SWITCH

FIG. 2

FIG. 3

FIG. 4A

FIG. 4B

FIG. 5A

FIG. 5B

FIG. 6A

FIG. 6B

FIG. 7A

FIG. 7B

30
1
3
54
POSITION DETECTOR
38
37
ULTRASONIC OBSERVER
39
55
COMPUTING UNIT
MONITOR
P
40
MIXER
33
LIQUID CRYSTAL DRIVER
34
57
FOOT SWITCH
56
MAGNIFICATION DETECTING MEANS

FIG. 8

54
POSITION DETECTOR
51 52 53
9
8
11
7
16
6
50
4
P
33
MONITOR
MIXER
12 17 13
14
LIQUID CRYSTAL DRIVER
34
MAGNIFICATION DETCTING MEANS
56

FIG. 9

FIG. 10A

FIG. 10B

FIG. 10C

FIG. 11A

FIG. 11B

FIG. 12

FIG. 13

FIG. 15A

FIG. 15B

FIG. 15C

FIG. 15D

FIG. 14C

FIG. 14F

FIG. 14B

FIG. 14E

FIG. 14A

FIG. 14D

FIG. 16

116
115
113
112
111
111a
110
109
LIGHT SOURCE
111c
111b
114
P

FIG. 17

117L
117R
121L
119L
116L
116R
120L
119L1
118L
119L2
115L
115R
119L3
POSITION A
114
P

FIG. 18

IMAGE -PICKUP DEVICE
121L
INPUT SWITCH FOR FLUORESCENT IMAGE OBSERVATION
122
124
DIGITIZER
123
128
VIDEO SIGNAL PROCESSOR
FILTER DRIVE CONTROLLER
WS
125
MOTOR 1
MOTOR 2
111c
119L3
MEMORY
129
MICROSCOPE BODY CONTROLLER
MONITOR
126
127
MIXER
130
MONITOR
131

FIG. 19

INPUT OPERATION FOR FLUORESCENT IMAGE OBSERVATION
A1
A2-2
ACTUATE FILTER DRIVE CONTROLLER
A2-1
DETECT OBSERVATION POSITION
FLUORESCENT SHOOTING
A3-1
SELECT PREOPERATIVE IMAGE IN FOCUS POSITION(B)
A3-2
BINARY-CODE FLUORESCENT SHOT IMAGE(A)
A4
SUPERPOSE (A) AND (B)
A5

FIG. 20

141
SYNTHESIS IN POSITION B
B
C
142
143
144
145a
145b
SYNTHESIS IN POSITION C
146a
146b

FIG. 21

121L
117L
117R
121R
133L
133R
134L
134R
132L
132R
120L
120R
119L
116L
116R
119L1
118L
118R
119R1
119L2
119R2
119L3
119R3
115L
115R
114
P

FIG. 22

135L
LEFT-HAND VIDEO SIGNAL PROCESSOR
136L
LEFT-HAND MEMORY
137L
LEFT-HAND MIXER
134L
MONITOR
135R
RIGHT-HAND VIDEO SIGNAL PROCESSOR
136R
RIGHT-HAND MEMORY
137R
RIGHT-HAND MIXER
134R
MONITOR
3D CONVERTER
139
3D MONITOR
140
TO 136L
TO 136R
122
INPUT SWITCH FOR FLUORESCENT IMAGE OBSERVATION
123
FILTER DRIVE CONTROLLER
138
BILATERAL SCREEN DIVIDING MEANS
MOTOR
111C
MOTOR
119R3
125
WS
MOTOR
119L3
124
DIGITIZER
MICROSCOPE BODY CONTROLLER
126

FIG. 23

135L
LEFT-HAND VIDEO SIGNAL PROCESSOR
136L
LEFT-HAND MEMORY
137L
LEFT-HAND MIXER
148L
LEFT-HAND IN-FIELD DISPLAY CONTROLLER
135R
RIGHT-HAND VIDEO SIGNAL PROCESSOR
136R
RIGHT-HAND MEMORY
137R
RIGHT-HAND MIXER
148R
RIGHT-HAND IN-FIELD DISPLAY CONTROLLER
3D CONVERTER
139
3D MONITOR
140
TO 136L
TO 136R
122
INPUT SWITCH FOR FLUORESCENT IMAGE OBSERVATION
123
FILTER DRIVE CONTROLLER
138
BILATERAL SCREEN DIVIDING MEANS
MOTOR
111C
MOTOR
119R3
125
WS
MOTOR
119L3
124
DIGITIZER
MICROSCOPE BODY CONTROLLER
126

FIG. 24

FIG. 25

FIG. 26

FIG. 27

205
208
209
211
210

FIG. 28

Lb
Lb1
212A
213b
214b
215b
213b1
216b
219b
220b
Lb2
217b
218b
214a
215a
212
213a
213a1
216a
218a
La
219a
220a
La2
217a

FIG. 29

CONTROLLER
229
222
221
CCTV UNIT
223
IN-FIELD IMAGE GENERATOR CIRCUIT
224b
MICROSCOPIC IMAGE MASKING PROCESSOR
228b
FIRST ROTATION COMPUTING CIRCUIT
230
SECOND ROTATION COMPUTING CIRCUIT
231
POSITION DETECTING ENCODER
211
IN-FIELD IMAGE GENERATOR CIRCUIT
224a
MICROSCOPIC IMAGE MASKING PROCESSOR
228a
Kb
DISPLAY CHANGING CIRCUIT
227b
227a
DISPLAY CHANGING CIRCUIT
Ka
LCD FOR MICROSCOPIC IMAGE MASKING
214b
THIRD LCD DRIVER
225b
LCD FOR IN-FIELD DISPLAY
219b
FOURTH LCD DRIVER
226b
LCD FOR MICROSCOPIC IMAGE MASKING
214a
FIRST LCD DRIVER
225a
LCD FOR IN-FIELD DISPLAY
219a
SECOND LCD DRIVER
226a

FIG. 30

FIG. 31A

FIG. 31B

FIG. 31C

FIG. 31D

FIG. 32A

FIG. 32B

FIG. 33A

FIG. 33B

FIG. 34A

FIG. 34B

FIG. 35A

FIG. 35B

CONTROLLER
229
222
221
CCTV UNIT
223
211
IN-FIELD IMAGE GENERATOR CIRCUIT
224b
MICROSCOPIC IMAGE MASKING PROCESSOR
228b
Lb
215b
216b
218b
217b
MOTOR CONTROL CIRCUIT
257
DISPLAY CHANGING CIRCUIT
227b
Lb1
Ld2
220b
254
Kb
THIRD LCD DRIVER
225b
252
214b
255
219b
253
FOURTH LCD DRIVER
226b
251
213b

FIG. 36

FIG. 37

FIG. 38A

FIG. 38B

285
281
284
294
283a
283
293
292
286
289
291
290
288
286
291
287
282

FIG. 39

FIG. 40A

FIG. 40B

FIG. 41A

FIG. 41B

FIG. 42A

FIG. 42B

404
0e
0c
0b
407
401
0a
406
408
0d
410
409
405
440
403
402b
402
402a

FIG. 43

442
442a
442b
443
CONTROLLER
MONITOR
CONTROLLER
454
449
0f
444
451c
448b
450
451e
0r
451d
452
0s
TO 52
448a
451b
441
CONTROL SECTION
453
0q
0g
447
0u
451a
446
445
0p
451a
451c
451d
451b
451d
451e

FIG. 44

452
453
CONTROL SECTION
451a–451e: SOLENOID BRAKE
442b
CONTROLLER
454
CONTROLLER
420
413
409
421
425b
422
423
424
417
S
416
412
415
414
424a
425a
411

FIG. 45

FIG. 46

FIG. 47

POSITION DETECTOR
463
TO 464
462
404
0c
407
408
0d
409
460
403
461
410
0e
440
406
0b
405
402b
402a
0a
401
402

FIG. 48

CONTROLLER
442b
464
463
0f
CONTROLLER
POSITION DETECTOR
417
469
466
467
470
471
468
420
465
416
411
412
415
414

FIG. 49

FIG. 50A

FIG. 50B

FIG. 52

FIG. 53A

FIG. 53B

417
0f
498
493
494
488
IMAGE APPARATUS
496
MOTOR DRIVE CONTROLLER
499
495
MEASUREMENT SECTION
487
490
0f
417
489
491
492
502
485
DISPLAY CONTROLLER
486
484
482
483
481
500
480
416
411
412
415
414

FIG. 51

FIG. 54

L
618
606
617
619
616
615
605
612
604
602
604a
604b
624
626
625
613
614
622
623
608
611
603
α
609
610
R
621
620
627

FIG. 55

601
02
03
633
630
0'1
632
635
606
04
L
631
634
604c
605
636
604
604b
604a
637
602
618
603
05
638
R
01

FIG. 56

606
617
616
649
650
651
648
654
652
653
656
631
638
641
604
649
640
657
646
615
605
642
604b
645
644
647
602
611
643
661
0'1
603
660
01
α
609
620

FIG. 57

601
W1
W2
604c
658
605
659
604
603

FIG. 58

601
02
633
03
670
635
04
672
L
671
632
634
605
673
636
604b
604a
604
637
602
618
603
0' 1
05
643
R

FIG. 59

606
672
675
671
617
616
677
618
602
605a
605
651
638
604
674
673
604a
615
680
686
688
687
676
604b
684
681
611
683
682
679
603
0'1
690
x
01
691
α
609
620

FIG. 60

686
684
683
681
680
90
682

FIG. 61

808b
809
803b
805
803a
803
806
808
807
808a
801
812
801a
810
802
811
α
01
13

FIG. 62

03
820a
808b
821a
817
809
815d
815c
04
r
816
r
811
815a
815
T1
808c
820c
815b
821c
808a
808
808a
812
821c
801
825d
820c
801a
05
825c
T2
r
811
r
825a
825a
810
825b
820a
827
821a
01

FIG. 63

820d
820a
808b
r
04
r
815
815b
820b
820c
821d
821b
821a
821c
820c
820b
05
r
r
825
825b
820d
820a
808a

FIG. 64

A3
B3
811
B3
805
C3
a3
809
d3
815
b3
c3
808
801
700
a3
811
d3
b3
810
813
01
c3

FIG. 65

A4
B4
D4
805
811
C4
M
a4
d4
809
815
b4
c4
808
801
a4
810
d4
811
b4
813
c4
01
700

FIG. 66

808b
830
807
808a
801a
801

FIG. 67

803
803b
803a
809
845
840
805
Y
Z
X
846
X
Y
843
842
Z
841a
808
801
810
700
841b
01
03

FIG. 68

808b
852
808c
846
899
847
848
848a
849
808a
03

FIG. 69

ENCODER
CONTROL CIRCUIT
MOTOR DRIVER
MOTOR
844
850
851
848

FIG. 70

803
803b
803a
h
i
860c
g
f
Y
Z
X
840
805
860b
843 (844)
842
863
e
860a
801
841a
860
Q
841b
865
861
862
862a

FIG. 71

FIG. 72
(PRIOR ART)

FIG. 73
(PRIOR ART)

FIG. 74 (PRIOR ART)

FIG. 75A
(PRIOR ART)

FIG. 75B
(PRIOR ART)

SURGICAL MICROSCOPIC SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from the prior Japanese Patent Applications No. 11-266687, filed Sep. 21, 1999; No. 11-288328, filed Oct. 8, 1999; No. 11-298250, filed Oct. 20, 1999; No. 11-312443, filed Nov. 2, 1999; No. 11-353212, filed Dec. 13, 1999; No. 11-354414, filed Dec. 14, 1999, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates to a surgical microscopic system adapted for microsurgery carried out under microscopic observation for neurosurgery, for example.

In order to ensure higher accuracy for a neurosurgical operation that uses an operating microscope, for example, treatment based on an endoscope, ultrasonic diagnostic apparatus, or any other diagnostic technique without the use of visible light is expected to be carried out for the tissues of regions that are not accessible to the operating microscope, such as the back or inside of an affected region, accompanied by real-time observation and diagnosis. Various surgical microscopic systems have been developed to meet this requirement.

Described in Jpn. Pat. Appln. KOKAI Publications Nos. 62-166310, 3-105305, 7-261094 are surgical observational systems in which an endoscope or the like is used to observe regions that correspond to dead angles of an operating microscope, and optical images of the observational regions are projected in the field of the microscope.

According to these conventional surgical observational systems, however, an observational image obtained by means of the endoscope or the like is only projected on the microscopic field, so that it is difficult for an operator to identify the endoscopic image that is actually observed through the field of the microscope. In the case where this technique is applied to a diagnostic apparatus, such as an ultrasonic diagnostic apparatus, which uses no visible light, the operator can hardly grasp an actually diagnosed part of a patient's body according to an image in the observational field only. Thus, the operator can discriminate the diagnosed region by the image only if s/he ideally superposes the characteristic features of the diagnostic image and the actual observational image, based on his or her experience.

Described in Jpn. Pat. Appln. KOKAI Publication No. 9-56669, moreover, is a surgical microscopic system with improved operativity, in which an endoscopic image or the like is displayed as a sub-picture in some other part of the microscopic field than the field portion where a main observational image is displayed. If the operator uses the system in combination with an endoscope or ultrasonic observer in this case, however, s/he is not provided with any means for grasping the region that is observed actually. Therefore, the operator can grasp the observational region only by randomly swinging the endoscope or ultrasonic probe in all directions and ideally superposing the characteristic features in comparison with a microscopic image.

Further, a method for guiding second observational means, such as an ultrasonic probe, into the field of an operating microscope is described in Jpn. Pat. Appln. KOKAI Publication No. 6-209953. According to this conventional technique, however, there is provided no method for effectively displaying the observational image of the second observational means in the microscopic field, so that the operator can correlate the microscopic optical image and the image of the second observational means only ideally.

Proposed in Jpn. Pat. Appln. No. 11-132688 filed by the assignee of the present invention (not published), furthermore, is a surgical microscopic system in which the direction of the observational field of an endoscope is indicated by an arrow or the like displayed in the field of a microscope. However, the microscopic optical image and the endoscopic image cannot be satisfactorily correlated by only indicating the observational direction in this manner. Thus, the operator can correlate these images only ideally in consideration of differences in rotation, magnification, etc. between them. If an ultrasonic observer is used as auxiliary observational means, moreover, the observational direction is not fixed, covering the circumferential angle of 360°, for example, so that it is hard to align observational image and an actual affected region.

Described in Jpn. Pat. Appln. KOKAI Publication No. 6-205793, moreover, is a display system that displays a preoperative diagnostic image by superposition on an image of an affected region by means of a half-mirror. Since the preoperative diagnostic image is superposed on the whole affected region image in this case, however, the microscopic field is too obscure to ensure a satisfactory actual surgical operation. Therefore, this system can only determine a preoperative position for craniotomy, and cannot accurately grasp information on the inner tissue in association with the affected region on a real-time basis during the surgical operation.

Described in Jpn. Pat. Appln. KOKAI Publication No. 9-24052, furthermore, is a method that uses fluorescent observation for the recognition of the position of a cerebral tumor, in order to extract the tumor securely under surgical microscopic observation. Although the observational tumor position can be securely recognized by this method, however, the obtained information is related only to the exposed surface of the tumor on the plane of observation at that time (during the extraction). Accordingly, information on the entire tumor (including information on inaccessible depths) inevitably depends on preoperative information.

Further, a navigation apparatus is proposed in Jpn. Pat. Appln. No. 10-248672 (not published). This navigation apparatus forms three-dimensional image data on the basis of image information from a CT scanner or MRI that is operated for a preoperative diagnosis, establishes a spatial correlation between a patient's head and the observational position of a microscope during a surgical operation, and supports the surgical operation in accordance with the three-dimensional image data. According to this navigation apparatus, the image of the entire tumor is obtained as slice image information for the observational point concerned during the surgical operation. However, only the slice image information for a focal position can be obtained on a three-dimensional observational plane of the operating microscope. Therefore, the operator must identify the position of the tumor by the slice image information with the progress of the operation.

With the recent development and spread of microsurgery, a technique for surgical operations for minute affected regions, moreover, operating microscopes have started to be extensively used for microsurgery in a wide variety of fields including ophthalmology, neurosurgery, otolaryngology, etc. Naturally, therefore, the operating microscopes are being improved to meet various requirements that depend on

operators' surgical maneuvers. Recently, surgical operations have been changed into less invasive ones in consideration of earlier rehabilitation of operated patients, so that there is a demand for the way of observation of affected regions in finer tubules. For improved accuracy and safety of surgical operations in the depths of the body cavity, furthermore, hidden regions that are inaccessible to microscopic observation are expected to made observable.

As a technique to meet these requirements, a stereoscopic operating microscope described in Jpn. Pat. Appln. KOKAI Publication No. 62-166310, for example, is designed so that the inside of a tubule can be observed by means of first and second stereoscopic optical systems with different base line intervals. Since the two stereoscopic optical systems shares a finder optical system, moreover, an operator can alternatively observe images from the two optical systems. This stereoscopic operating microscope is provided with the stereoscopic optical system that includes the finder optical system and a pair of variable-magnification optical systems, left and right, having the same optical axis. An auxiliary stereoscopic optical system that is located near the main stereoscopic optical system includes image restoring means for reproducing an image from a solid-state image-pickup device for picking up an image of an observed object and image projecting means for guiding the image to the finder optical system of the stereoscopic optical system.

An optical device described in Jpn. Pat. Appln. KOKAI Publications No. 3-105305 is designed so that one or both of images from two observational means of a stereoscopic operating microscope can be alternatively observed and that the operator can select the images by means of a footswitch or the like without using his or her hand.

A system described in Jpn. Pat. Appln. KOKAI Publication No. 6-175033, moreover, is provided with position specifying means for specifying a position in or near the observational field. In this system, the relation between a reference position of an operating microscope and the position specified by means of the position specifying means is computed, and the body of the microscope is moved to the specified position.

Described in Jpn. Pat. Appln. No. 10-319190 filed by the assignee of the present invention (1998, not published), furthermore, is a system provided with drive means that causes an operating microscope and a robot manipulator to move to target positions in accordance with a preoperative diagnostic image or slice image information, thereby correlating the preoperative image and the operative field.

If the operator uses an auxiliary optical system for tubule observation to observe dead-angle regions that are inaccessible to microscopic observation, e.g., the back side of the an aneurysm, nerves cleared of a tumor, peripheral tissues, etc., as in the prior art case mentioned before, a video image picked up by means of an endoscope or other auxiliary optical system is displayed in the microscopic field. In this case, the operator's mate sometimes may observe a similar image as s/he aspirates the marrow or blood to secure the operator's field of vision.

FIGS. **74** shows an example of the system of an operating microscope a of this type. A body b of the microscope a is provided with an operator eyepiece unit c**1** and a mate eyepiece unit c**2**. An in-field monitor (not shown) is located in a part of the field of each of the eyepiece units c**1** and c**2**. As shown in FIGS. **75**A and **75**B, indexes and sub-images e**1** and e**2** that are different from main images d**1** and d**2** of the operating microscope a are projected in the main images d**1** and d**2**.

An LCD driver f is connected to each in-field monitor. Further, a CCTV unit g is connected to the LCD driver f. A camera head i is connected to the CCTV unit q. An endoscopic image observed by means of an endoscope h is displayed on the respective in-field monitors of the operator and mate eyepiece units c**1** and c**2**.

When a conventional operating microscope apparatus is used, moreover, an operative field j as an object of a surgical operation is observed at different angles by means of the microscope body b and the endoscope h. An optical video image then caught by the endoscope h is photoelectrically converted by means of a image-pickup device (not shown) in the TV camera head i and applied as an electrical signal to the TV camera head i to be processed therein, whereupon a TV signal is outputted. This TV signal is converted into a display mode signal of a liquid crystal display device (not shown) by means of the LCD driver f. This signal is delivered to liquid crystal image display devices (not shown) of the respective in-field monitors of the operator and mate eyepiece units c**1** and c**2** of the microscope a. Thereupon, endoscopic images are partially displayed as the sub-images e**1** and e**2** on the main images d**1** and d**2** of the microscope a in the microscopic field, as shown in FIGS. **75**A and **75**B. More specifically, in the operator eyepiece unit c**1** of this operating microscope apparatus, the sub-image e**1**, an endoscopic image, is inserted into the main image d**1** in the field of the microscope a by means of the liquid crystal image display device (not shown), as shown in FIG. **75**A. Likewise, in the mate eyepiece unit c**2**, the sub-image e**2**, an endoscopic image, is inserted into the main image d**2** in the field of the microscope a by means of the liquid crystal image display device (not shown), as shown in FIG. **75**B.

According to this operating microscope apparatus, however, the operator and the mate have their respective observational directions. Therefore, the relation between the display position of the main image d**1** in the field of the operator eyepiece unit c**1** of the microscope a and the display position of the sub-image e**1** in the same field is different from the relation between the display position of the main image d**2** in the field of the mate eyepiece unit c**2** of the microscope a and the display position of the sub-image e**2** in the same field. Since the field direction of the mate is different from that of the operator, the position in the mate-side observational optical system where the in-field display image appears is inevitably different from the corresponding position in the operator-side observational optical system. Possibly, therefore, a region that can be observed through the operator-side optical system may not be able to be observed through the mate-side optical system.

Basically, moreover, the field direction on the mate side is different from the operator-side field direction. Although the microscope images are located in correct relative positions, therefore, the positional relation between the images obtained by means of the auxiliary optical system cannot be displayed correctly. Since the mate-side observational optical system is rotatable with respect to the operator-side system, furthermore, the positional relation between the images of the auxiliary optical system goes wrong if the mate-side system is rotated. If bleeding or the like occurs in any region corresponding to a dead angle of the image of the auxiliary optical system in the mate-side field, therefore, the display position of the auxiliary optical system must be controlled manually.

In carrying out a surgical operation with reference to a diagnostic image, furthermore, a preoperative diagnostic image, such as MRI or X-ray CT, sometimes may be display as each of the sub-images e**1** and e**2** on the video images in

the main images d1 and d2 in the field of the microscope a. In this case, these sub-images, unlike the aforesaid video image of the auxiliary optical system, should never fail to be erect images, and the images that are accessible to the operator and the mate, individually, must be of the same type.

In the case where the operating microscope apparatus is used in combination with a position information detector or the like, moreover, a position information detection image and a marker for the detector must be overlaid on a microscopic image. A conventional microscopic apparatus with in-field display means requires use of one combination of an optical system and a display device for the display of an image in the microscopic field and another for the display of a marker. If the image and the marker are needed simultaneously, therefore, the display device must be changed during use or one of the devices must be replaced with an alternative device.

Conventionally, furthermore, the operator is expected to confirm the marker display of the position information detector and manually move the microscope body to the marker position. Accordingly, highly complicated maneuvers are required by a technique that uses the position information detector in combination with an auxiliary optical system such as an endoscope.

In order to make a microsurgical operation less invasive, moreover, various pieces of image information are used during the operation. The image information may be obtained by means of an endoscope for observing regions that are inaccessible to the operating microscope or an ultrasonic observer for obtaining a slice image of the inside of tissue. Further, it may be obtained by means of a diagnostic device such as a so-called nerve monitor device for measuring the potential of nerves of a patient under the operation. To attain this, an operating microscope for the observation of an endoscopic image or the like is described in Jpn. Pat. Appln. KOKAI Publication No. 10-333047, as in Jpn. Pat. Appln. KOKAI Publication No. 62-166310.

A microscope requires visibility adjustment or adjustment of differences in eyesight (refractive force) between observers. A technique for this visibility adjustment is described in Jpn. Pat. Appln. KOKAI Publication No. 7-281103. An operating microscope is also subjected to the visibility adjustment with every surgical operation. On the other hand, a method for measuring the refractive force of an eye is described in Jpn. Pat. Appln. KOKAI Publication No. 3-200914. In this method, however, the refractive force of an eye of a patient, not an observer, is measured by projecting an index on the eyeground and detecting light reflected by the eyeground.

The operating microscope described in Jpn. Pat. Appln. KOKAI Publication No. 10-333047 can perform microscopic observation and endoscopic observation in one and the same field. When an endoscope is moved in an affected region, however, its distal end must be checked for the location on a microscopic image lest it damage tissue as an endoscopic image is observed. It is to be desired, therefore, that the endoscopic image should not intercept the microscopic field or should be displayed small on the microscopic image.

When the endoscopic image is watched as a treatment or the like is carried out, on the other hand, it is expected to be wide enough. Observation based on the microscopic image is also needed to check an instrument for insertion or watch a wide range of the affected region. Thus, it is advisable to display the endoscopic image large on the microscopic image.

In each of the operating microscopes described in Jpn. Pat. Appln. KOKAI Publications Nos. 62-166310 and 10-333047, however, the endoscopic image is displayed in a fixed position and within a fixed range in the microscopic field. Therefore, a surgical operation using the endoscope cannot easily meet the demand for both the movement of the endoscope and the treatment with reference to the endoscopic image, and the endoscopic image may be obstructive or too small for smooth treatment.

Thus, it is hard for an operator to concentrate his or her attention on the surgical operation, so that the operator's fatigue increases, and the operation time extends. An ultrasonic diagnostic apparatus is subject to the same problems when its probe is moved or when ultrasonic observation or treatment under ultrasonic observation is carried out. Since the endoscope used under surgical microscopic observation is designed for the observation of regions corresponding to dead angles of the microscope, moreover, it should be of a squint type for observation in directions different from the direction of its insertion. If the squint-type endoscope is rotated around the direction of insertion, it ceases to be able to identify the direction of view with respect to the microscopic field. Accordingly, the operator must judge the observational direction by a tissue form displayed in the endoscopic image. Thus, it is hard for the operator to be devoted to the surgical operation, so that the operator's fatigue increases, and the operation time extends. Even when the operator is concentrating his or her attention on the observational image of the operating microscope, furthermore, s/he must also pay attention to the state of some other equipment to detect a change in the nerve monitor device, so that his or her fatigue is increased.

On the other hand, the conventional visibility adjustment operation described in Jpn. Pat. Appln. KOKAI Publication No. 7-281103 is troublesome and lengthens the setup time before the start of operation of the operating microscope. If the operator changes during a surgical operation, moreover, the visibility must be readjusted. Usually, it is difficult to adjust the visibility with a drape for sterilization on the microscope. If the microscope is used with wrong visibility, the surgical operation is performed with the right or left eye of the operator out of focus, so that the operator is fatigued much. Further, a TV camera or 35-mm camera that is connected to the operating microscope may fail to be in focus. In this case, the refractive index of the operator's eye may be able to be measured automatically to correct the visibility by the method described in Jpn. Pat. Appln. KOKAI Publication No. 3-200914. According to this method, however, an optical system must be provided with an index projection optical system for detection and its mating light receiving optical system, so that a large-sized apparatus is required, constituting a hindrance to the surgical operation. Even if projected light has a wavelength in an invisible zone, its influence upon the observational performance of the microscope cannot be removed thoroughly, so that the efficiency of the surgical operation is lowered, and the operator is fatigued inevitably.

A rigid scope may be used for the observation of regions corresponding to dead angles of the operating microscope in microsurgery. In this case, the observation of the dead-angle regions requires use of a so-called squint-type rigid scope for oblique observation at a fixed angle (e.g., 30°, 70° or 110°) to the observational optical axis of its eyepiece. In this rigid scope, a TV camera (image-pickup device) is connected to the eyepiece to display its observational image on a monitor screen. The rigid scope is also connected with a light guide, which is connected to a light source unit to guide

illumination light to an affected region. In order to observe a region corresponding to a dead angle of the operating microscope, the rigid scope of this type is used in a very narrow space (normally about 300 mm) between the body of the microscope and the observational region. To change its squint angle, moreover, the rigid scope can be rotated throughout the angular range of 360° with respect to the direction of its insertion during a surgical operation. Thus, the operator can observe his or her desired position.

In a rigid scope described in Jpn. UM Appln. KOKAI Publication No. 5-78201, a TV camera is connected optically to the imaging point of its eyepiece. A light guide that constitutes an illumination optical system in the rigid scope and a light guide one end of which is connected to a light source unit are connected optically to each other in a position near the eyepiece. Since the TV camera itself projects in the direction of insertion of the rigid scope, however, it may possibly interfere with the operating microscope body, depending on the direction of insertion of the scope into the body cavity, so that the operator's desired observational position is restricted inevitably. Further, the light guide that is connected to the light source unit projects substantially at right angles to the direction of insertion into the body cavity. If the operator rotates the rigid scope around the direction of insertion to change the observational direction, therefore, the light guide may get deep into the field of the microscope depending on its direction, thereby hindering the microscopic observation.

In a rigid scope described in U.S. Pat. No. 5,168,863, moreover, cables of a TV camera that is connected to an eyepiece are guided in a direction at about 45° to its longitudinal direction (direction of insertion into the body cavity). In this case, the TV camera can somewhat be prevented from interfering with the body of an operating microscope. Nevertheless, the TV camera itself still causes interference, and the light guide extensively intercepts the microscopic field as the rigid scope rotates.

In a rigid scope described in Jpn. UM Appln. KOKAI Publication No. 56-176703, furthermore, a reflective member for bending the observational optical axis is disposed on an observational optical system therein so that the optical axis of an eyepiece is inclined at a fixed angle to the longitudinal direction of the scope (direction of insertion into the body cavity). Since the a part of the eyepiece portion of this rigid scope is inclined at the fixed angle to the direction of insertion of the scope, a TV camera can avoid interfering with the body of an operating microscope. Since the direction of projection of a light guide is coincident with the direction of insertion into the body cavity, however, the light guide and the microscope body inevitably interfere with each other.

A rigid scope described in Jpn. Pat. Appln. KOKAI Publication No. 11-155798, like the one described in Jpn. UM Appln. KOKAI Publication No. 56-176703, is designed so that the observational optical axis of an eyepiece is inclined at a fixed angle to its longitudinal direction (direction of insertion into the body cavity), and a light guide, which is connected to a light source unit, is connectable near the eyepiece. In either of the rigid scopes described in Jpn. UM Appln. KOKAI Publication No. 56-176703 and Jpn. Pat. Appln. KOKAI Publication No. 11-155798, however, the eyepiece and the TV cam attached thereto project long within a plane at about 90° to the direction of insertion of the rigid scope into the body cavity (i.e., region for the operator's surgical operation), so that they inevitably intercept the space for the surgical operation, thereby hindering the operation. When the operator rotates the rigid scope around the direction of insertion into the body cavity to change the observational direction, in particular, the scope moves in an arc of a circle having a radius that is equal to the sum of the respective overall lengths of the eyepiece, TV camera, cables, etc., thus constituting a great hindrance to the operation. Depending on the observational direction, moreover, the TV camera and the light guide may interfere with the operator's hand or body, so that they may possibly lower the efficiency of the surgical operation.

BRIEF SUMMARY OF THE INVENTION

The present invention has been contrived in consideration of these circumstances.

An object of the present invention is to improve the efficiency of a surgical operation by simultaneously displaying a plurality of pieces of information required by an operator in the field of a microscope during microsurgery so that the operator can be fed with necessary information as required.

Another object of the invention is to display a real-time observational image of second observational means effectively in association with an observational image of first observational means in the field of the first observational means in a microscope body.

Still another object of the invention is to provide a surgical microscopic system designed so that an operator can easily grasp the progress of an surgical operation during the operation, whereby the operation can be carried out more securely and safely.

A further object of the invention is to provide a surgical microscopic system designed so that necessary in-field information can be appropriately offered to an operator or his or her mate, and that a required microscopic field can be easily secured during a surgical operation.

An additional object of the invention is to provide a surgical microscopic system designed so that an operator can be devoted to a surgical operation, his or her fatigue can be eased, and the operation time can be shortened.

Furthermore, the invention is intended to improve a rigid scope that can be inserted into the body cavity under surgical microscopic observation, thereby enabling observation at a fixed angle to the direction of insertion, to prevent the rigid scope and a TV camera or light guides connected thereto from hindering the microscopic observation or surgical treatment, and to enable an operator to observe a desired position with ease.

In order to achieve the above objects, according to an aspect of the invention, there is provided an operating microscope apparatus comprising: at least one microscope body defining an observational field for observing an affected region; first image display means for displaying a first image in the observational field; second image display means for displaying a second image in the observational field; and image display control means for displaying independent images on the first and second image display means, individually.

The microscope body may include an optical image displayed in the observational field. In this case, the operating microscope apparatus may comprise second observational means different from an operating microscope and selected from a group including an endoscope and an ultrasonic probe. Further, the second image display means may include an image superposition optical system for superposing an image on the optical image in the observational field. Preferably, the image display control means

includes means for independently switching on and off the first and second image display means.

In the case where the operating microscope apparatus comprises second observational means different from an operating microscope and selected from a group including an endoscope and an ultrasonic probe, the first and second images preferably include (i) a combination of an observational image obtained by means of the second observational means and an image (navigation image) indicative of the observational position or direction of the second observational means or (ii) a combination of a tumor position display marker image and a preoperative/mid-operative diagnostic image selected from a group including image-processed fluorescent observational images and the image (navigation image) indicative of the observational position or direction of the second observational means.

According to another aspect of the invention, there is provided a surgical observational system including first observational means for observing an affected region and second observational means different from the first observational means at least in the observational direction or observational method. This system comprises detecting means for detecting the respective observational positions and directions of the first and second observational means relative to the position of the affected region; and display means for displaying an observational image of the second observational means in a given part of an observational image of the first observational means in visual correlation based on the relative positions detected by means of the detecting means. According to this surgical observational system, the image of the second observational means is correlatively displayed in a part of the observational image of the first observational means. Thus, the respective observational positions of the first and second observational means are detected on the basis of the affected region by means of an optical position detector, for example. The observational image of a corresponding portion of the second observational means can be cut out into a given position of the observational image of the first observational means to adjust the image size for display.

Alternatively, the surgical observational system may comprise detecting means for previously storing a preoperative diagnostic image and detecting the observational position of the second observational means relative to the preoperative diagnostic image; and display means for simultaneously displaying the preoperative diagnostic image concurrent with the observational position of the second observational means and the observational image of the second observational means in the field of the first observational means in accordance with the relative positions detected by means of the detecting means. In this case, the observational position of the second observational means is detected on the basis of the affected region by means of an optical position detector, for example. The observational image of the second observational means is displayed in the field of the observational image of the first observational means, and at the same time, a part of the preoperative diagnostic image corresponding to the observational position of the second observational means is displayed in the observational field of the first observational means.

According to this surgical observational system, at least a part of the observational image of the second observational means is displayed in the observational field of the first observational means for the observation of the affected region in a manner such that its position, size, etc. are associated with those of the observational field of the first observational means. Accordingly, the states of dead angle portions and the inside of tissue that cannot be observed by means of the first observational means can be recognized easily and securely, so that the reliability and efficiency of the surgical operation can be improved considerably.

On the other hand, the surgical observational system may comprise detecting means for detecting the respective observational positions and directions of the first and second observational means relative to the position of the affected region; an indicator indicative of an optional position in the observational field of the first observational means; and display means capable of following the indicator and displaying an observational image for a given range in the observational field of the first observational means by superposition. According to this surgical observational system, as in the case of the system described above, the image of the second observational means can be correlatively displayed in a part of the observational image of the first observational means. An operator can operate the indicator to set an optional position in the observational field of the first observational means. The observational image of the second observational means is displayed in a given range of the indicator after is cut out and subjected to size adjustment. Thus, the affected region in the peripheral portion and the observational image of the second observational means can be correlated with ease, and treatment can be carried out smoothly, so that the efficiency of the surgical operation can be improved.

According to still another aspect of the invention, there is provided an operating microscope apparatus for subjecting an affected region to a surgical operation, comprising: a microscope body including a stereoscopic optical system and used to observe a desired region; position computing means for detecting the position of the observational region observed through the stereoscopic optical system and computing the positional relation between the observational region and a diagnostic image of the affected region; fluorescent shooting means for shooting fluorescent images of the observational region, thereby obtaining fluorescent observational images; and display means for displaying, by superposition, the diagnostic image corresponding to the position of the observational region detected by means of the position computing means and the fluorescent observational images obtained by means of the fluorescent shooting means.

This operating microscope apparatus may comprise storage means for storing the fluorescent observational images. In this case, the display means displays the diagnostic image corresponding to the observational position detected by means of the position computing means and the fluorescent observational images stored in the storage means, by superposition on the observational image of the affected region. Further, the operating microscope apparatus may comprise display mode setting means capable of setting an optional display mode. In this case, the display means displays the diagnostic image corresponding to the observational position detected by means of the position computing means and the fluorescent observational images stored in the storage means, by superposition on the observational image of the affected region, in accordance with the setup state of the display mode setting means.

According to this operating microscope apparatus, the fluorescent observational images shot by means of the fluorescent shooting means and the diagnostic image selected according to the observational position detected by means of the position computing means are displayed by superposition, so that the operator can accurately recognize the conditions of a tumor to be extracted. Thus, the operator

can carry out extraction more accurately and be devoted to the extracting operation. Further, only the tumor portion can be extracted securely, so that the object for minimally invasive surgery can be achieved.

According to the present invention, moreover, there is provided an operating microscope apparatus for subjecting an affected region to a surgical operation, comprising: a microscope body including a stereoscopic optical system and used to observe a desired region; position computing means for detecting the position of the observational region observed through the stereoscopic optical system and computing the positional relation between the observational region and a diagnostic image of the affected region; fluorescent shooting means for stereoscopically shooting fluorescent images of the observational region, thereby obtaining fluorescent observational images; storage means for storing the fluorescent observational images; image dividing means for dividing the diagnostic image corresponding to the observational position detected by means of the position computing means into two image signals having a lateral parallax; and display means for displaying the individual stored fluorescent observational images and the laterally divided diagnostic images by superposition on the observational image of the affected region.

Likewise, there is provided an operating microscope apparatus for subjecting an affected region to a surgical operation, comprising: a microscope body including a stereoscopic optical system and used to observe a desired region; position computing means for detecting the position of the observational region observed through the stereoscopic optical system and computing the positional relation between the observational region and a diagnostic image of the affected region; fluorescent shooting means for stereoscopically shooting fluorescent images of the microscopic observational region, thereby obtaining fluorescent observational images; storage means for storing the fluorescent observational images; display mode setting means capable of setting an optional display mode; image dividing means for dividing the diagnostic image corresponding to the observational position detected by means of the position computing means into two image signals having a lateral parallax; superposing means for superposing the individual stored fluorescent observational images and the laterally divided diagnostic images on the observational image of the affected region in accordance with the setup state of the display mode setting means; and a lens tube portion having a monitor portion for displaying the individual images.

The fluorescent shooting means may be designed for stereoscopic shooting of the fluorescent images of the observational region. In this case, the operating microscope apparatus comprises image dividing means for dividing the diagnostic image corresponding to the observational position detected by means of the position computing means into two image signals having a lateral parallax. The display means can display the individual stored fluorescent observational images and the laterally divided diagnostic images by superposition on the observational image of the affected region.

Further, the operating microscope apparatus may comprise a lens tube portion having a monitor portion for displaying the individual images.

Furthermore, the display means may be designed to display, by superposition, the slice image corresponding to the observational position detected by means of the position computing means and the fluorescent observational images obtained by means of the fluorescent shooting means. This operating microscope apparatus may comprise display mode setting means capable of setting an optional display mode. In this case, the display means displays the slice image corresponding to the observational position detected by means of the position computing means and the fluorescent observational images stored in the storage means, by superposition on the observational image of the affected region, in accordance with the setup state of the display mode setting means.

According to a further aspect of the invention, there is provided an operating microscope apparatus including a plurality of eyepiece units capable of relative movement and individually having fields capable of displaying one and the same region as a main image and in-field monitors provided individually for the eyepiece units and each adapted to project an index and/or a sub-image different from the main image on a part of the field, comprising: input means for applying observation conditions to one of the eyepiece units; and observational state changing means for changing the observational state of the other eyepiece unit according to the conditions. Thus, necessary in-field information can be appropriately offered to the operator or his or her mate, and a target microscopic field can be easily secured during a surgical operation. Preferably, the observational state changing means includes detecting means for detecting the position of the one eyepiece unit relative to the other eyepiece unit, an in-field display control means for controlling the display position of the in-field monitor of at least the one eyepiece unit to change the observational region in accordance with the result of detection by the detecting means, shielding means for selectively intercepting the optical image of the eyepiece units, and image rotating means for rotating the image of the in-field monitor in response to the output of the position detecting means. In this case, an optimum image display method can be provided even for a fixed-direction image, such as a preoperative image, and overlay display of the index by means of a position information detector and the operation of the detector can be carried out with ease. Further, the display method can secure a satisfactory degree of freedom for the operator and the mate.

The sub-image may be a diagnostic image. Preferably, in this case, the operating microscope apparatus comprises index manipulating means for changing the in-field index position on the diagnostic image and a position information computing unit for computing the three-dimensional position of an actual affected region relative to the position of the index displayed by means of the index manipulating means, and the position information computing unit and the in-field display control means drive the observational region of the operating microscope to the three-dimensional position.

Preferably, the operating microscope apparatus further comprises an image processing unit for image map conversion, adapted synchronously to rotate the image of the in-field monitor and the shielding means formed of the liquid crystal device in response to the output of the relative position detecting means.

According to an additional aspect of the invention, there is provided an operating microscope comprising: a first observational optical system for optically enlarging an affected region; a second observational optical system for observing optional image information from an external apparatus; and an eyepiece optical system for simultaneously observing observational images of the first and second observational optical systems, the second optical system including display state changing means capable of changing the display state of the image information from the

external apparatus in accordance with operation information from the external apparatus. The first and second observational optical systems are different from each other.

According to this operating microscope, if the operating state of the external apparatus is changed when the observational images of the first and second observational optical systems are simultaneously displayed, the image observed by means of the second observational means is automatically changed into a suitable state for a surgical operation. A small endoscopic image is displayed when an endoscope is moved in the affected region, for example. The displayed endoscopic image is large enough when it is watched as treatment or the like is carried out. Thus, according to this operating microscope, the display state of the display image in the microscopic field can be automatically changed in accordance with the operating state of the external apparatus, so that the operator can be devoted to the surgical operation, his or her fatigue can be eased, and the operation time can be shortened. This microscope is particularly serviceable if it is used with an ultrasonic observer for obtaining a slice image of the inside of tissue or a so-called nerve monitor device for measuring the potential of nerves of a patient under the operation, as well as the endoscope for observing regions that are inaccessible to the operating microscope.

Further, there is provided an operating microscope comprising: a first observational optical system for enlarged-scale optical observation of an affected region; a second observational optical system for observing optional image information from an external apparatus, the second observational optical system being different from the first observational optical system, and an eyepiece optical system for simultaneously observing observational images of the first and second observational optical systems. The second optical system includes fixed-view image display means for an observer's close observation, an index projection optical system for the eyeground, and an image receiving optical system for receiving reflected light from the eyeground. The operating microscope further comprises detecting means for computing refractive force in accordance with information from the image receiving optical system and visibility adjustment drive control means for driving a visibility adjustment mechanism in accordance with information from the detecting means. According to this operating microscope, the sight or refractive force of an observing eye is measured through the second observational optical system. Based on this refractive force, the visibility adjustment drive control means automatically carries out visibility adjustment. Thus, the operating microscope can be reduced in size without lowering its observational performance, and the operator can concentrate his or her attention on the operation without fatigue.

The display state changing means may include operation input portion for inputting the operation information from the external apparatus, optical changing means capable of optically changing the display state of the image information of the second observational optical system compared to the observational image of the first observational optical system, and control means for actuating the optical changing means in accordance with input information from the operation input portion. Preferably, the optical changing means includes magnification changing means capable of changing the magnification of the second observational optical system. According to this operating microscope, the size of each endoscopic image in the microscopic field can be changed in accordance with the movement and observational state of the endoscope. Thus, when the endoscope is moved, a small endoscopic image is displayed such that the distal end of the endoscope can be satisfactorily observed through the microscope. During endoscopic observation, on the other hand, a large image is displayed to facilitate treatment. If a squint-type endoscope for observation in directions different from the direction of insertion is used and rotated around the direction of insertion to observe regions corresponding to dead angles of the microscope, therefore, the observational direction of the endoscope compared to the microscopic field can be identified with ease.

Preferably, the optical changing means includes magnification changing means capable of changing the magnification of the second observational optical system or display position changing means capable of changing the position of the second observational optical system relative to the first observational optical system. The magnification changing means may be lens moving means for moving a variable-magnification optical system constituting the second observational optical system. Thus, there is provided an operating microscope in which the observational direction of an endoscope compared to the microscopic image can be recognized with ease.

The display position changing means may include rotating means for rotating the second observational means around the optical axis of the first observational means. Even when the operator is concentrating his or her attention on the observational image of the operating microscope, in this case, s/he can readily notice a change in the nerve monitor device. Thus, the operator can be devoted to the surgical operation, and his or her fatigue can be eased.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred embodiments of the invention, and together with the general description given above and the detailed description of the preferred embodiments given below, serve to explain the principles of the invention.

FIG. **1** is a view showing an outline of an operating microscope for use as first observational means of a surgical observational system according to a first embodiment;

FIG. **2** is a block diagram of the surgical observational system according to the first embodiment;

FIG. **3** is a detailed view for illustrating a microscope body portion of the operating microscope;

FIGS. **4**A and **4**B are views showing a state in which the whole surface of a first liquid crystal shutter is transmittable and a state in which a partial shading portion is provided in the shutter, respectively;

FIGS. **5**A and **5**B are views showing a state in which the whole surface of a second liquid crystal shutter is interceptive and a state in which a partial transparent portion is provided in the shutter, respectively;

FIGS. **6**A and **6**B are views individually showing images observed by an operator, in which FIG. **6**A shows only an optical image obtained when the whole surface of the first liquid crystal shutter is transmittable, and FIG. **6**B shows a

state in which an image obtained by means of an ultrasonic probe is displayed in a microscopic field;

FIG. **7**A is a view showing an image obtained by means of the ultrasonic probe and displayed on a monitor;

FIG. **7**B is a view showing a state in which the image obtained by means of the ultrasonic probe is reduced to a given size;

FIG. **8** is a block diagram of a surgical observational system according to a second embodiment;

FIG. **9** is a detailed view for illustrating a microscope body portion of an operating microscope;

FIGS. **10**A to **10**C are views individually showing various states of an image in the microscopic field observed by the operator, in which FIG. **10**A shows an ultrasonic image obtained by means of the ultrasonic probe, FIG. **10**B shows a preoperative diagnostic image, and FIG. **10**C shows the preoperative diagnostic image and the ultrasonic diagnostic image in association with an actual affected region;

FIGS. **11**A and **11**B are views individually showing observational images according to the second embodiment, in which FIG. **11**A shows the ultrasonic probe having its central portion extracted by means of a mixer, and FIG. **11**B shows an image actually observed by the operator;

FIG. **12** is a general block diagram of a surgical observational system according to a third embodiment;

FIG. **13** is a view showing the way an observational image of a rigid scope for use as second observational means according to the third embodiment is displayed on a monitor;

FIGS. **14**A to **14**F illustrate the respective operations of first and second liquid crystal shutters according to the third embodiment, in which FIGS. **14**A and **14**B are views showing the relation between a shading portion and a transparent portion, FIG. **14**C is a view showing a state of display on a monitor, and FIGS. **14**D to **14**F are views similar to FIGS. **14**A to **14**C, showing the shading portion and the transparent portion shifted in position;

FIGS. **15**A to **15**D show images observed by the operator according to the third embodiment and illustrate various positional relations between the image obtained by means of the rigid scope and an optical image obtained by means of the microscope;

FIG. **16** is a view showing a configuration of an operating microscope according to a fourth embodiment of the invention;

FIG. **17** is a view showing a configuration of an illumination system of the operating microscope;

FIG. **18** is a view showing a configuration of an observational optical system of the operating microscope;

FIG. **19** is a general functional block diagram of the operating microscope;

FIG. **20** is a chart for illustrating the operation of the invention;

FIG. **21** is a view for illustrating the way of synthesizing a fluorescent observational image and a two-dimensional preoperative slice image;

FIG. **22** is a view showing a configuration of an observational optical system according to a fifth embodiment of the invention;

FIG. **23** is a general functional block diagram of an operating microscope;

FIG. **24** is a general functional block diagram of an operating microscope according to a sixth embodiment of the invention;

FIG. **25** is a three-dimensional exterior view of a tumor;

FIG. **26** is a view for illustrating the effect of the sixth embodiment of the invention;

FIG. **27** is a side view showing the general external appearance of an operating microscope apparatus according to a seventh embodiment of the invention;

FIG. **28** is a side view showing a configuration of a microscope body of the operating microscope apparatus according to the seventh embodiment;

FIG. **29** is a schematic view of an optical system of the operating microscope apparatus according to the seventh embodiment;

FIG. **30** is a block diagram of an electric circuit of the operating microscope apparatus according to the seventh embodiment;

FIG. **31**A is a plan view showing a state in which a mask portion is inserted in a microscopic image of an operator-side optical system of the operating microscope apparatus according to the seventh embodiment;

FIG. **31**B is a plan view showing plan view showing a state in which an endoscopic image is partially displayed on an in-field image;

FIGS. **31**C and **31**D are plan views showing images obtained by rotating the images of FIGS. **31**A and **31**B, respectively;

FIGS. **32**A and **32**B show in-field images in a state such that endoscopic images are inserted individually in operator- and mate-side microscopic images of the operating microscope apparatus according to the seventh embodiment;

FIGS. **33**A and **33**B are plan views showing operator- and mate-use microscopic images, respectively, in the operating microscope apparatus according to the seventh embodiment;

FIGS. **34**A and **34**B are plan views showing a mask image and a in-field display image, respectively, obtained when an index is overlaid on each microscopic image in the operating microscope apparatus according to the seventh embodiment;

FIGS. **35**A and **35**B are plan views showing indexes superposed individually on the operator- and mate-use microscopic images, respectively, in the operating microscope apparatus according to the seventh embodiment;

FIG. **36** is a schematic view of a mate-side optical system of an operating microscope apparatus according to an eighth embodiment of the invention;

FIG. **37** is a plan view showing an outline of a drive mechanism for a microscopic image mask LCD of the operating microscope apparatus according to the eighth embodiment;

FIG. **38**A is a plan view showing an outline of a drive mechanism for a microscopic image mask LCD of an operating microscope apparatus according to a ninth embodiment of the invention;

FIG. **38**B is a plan view showing an outline of a drive mechanism for a microscopic image mask LCD of an operating microscope apparatus according to a tenth embodiment of the invention;

FIG. **39** is a general schematic view of an operating microscope apparatus according to an eleventh embodiment of the invention;

FIG. **40**A is a plan view showing a microscopic image in an operating microscope apparatus according to the eleventh embodiment;

FIG. **40**B is a perspective view showing an index/in-field display controller;

FIG. **41**A is a plan view showing a state in which a microscopic image mask as large as an in-field display

image is displayed on a microscopic image mask LCD of the operating microscope apparatus according to the eleventh embodiment;

FIG. **41**B is a plan view showing a state in which an index and a marker are displayed on the in-field display image;

FIG. **42**A is a plan view showing a microscopic image in the operating microscope apparatus according to the eleventh embodiment;

FIG. **42**B is a plan view showing a state in which an index and a marker are displayed on the microscopic image by superposition;

FIG. **43** is a view schematically showing an outline of an operating microscope and an endoscopic apparatus according to a twelfth embodiment;

FIG. **44** is a schematic view showing an endoscopic system along with a scope holder for supporting an endoscope shown in FIG. **43**;

FIG. **45** is a view showing an outline of a binocular tube of the operating microscope of FIG. **43**;

FIG. **46** is a view showing an observational state of the operating microscope for the case where an endoscopic image is mainly observed as a surgical operation is carried out;

FIG. **47** is a view similar to FIG. **46**, showing an observational state of the operating microscope for the case where the observational position of the endoscope is moved;

FIG. **48** is a view similar to FIG. **43**, schematically showing an outline of an operating microscope and an endoscopic system according to a thirteenth embodiment;

FIG. **49** is a view showing an outline of a binocular tube of the operating microscope of FIG. **48**;

FIGS. **50**A and **50**B are views individually showing states of observation through an eyepiece optical system of the binocular tube shown in FIG. **49**;

FIG. **51** is a view illustrating a binocular tube optical system of an operating microscope according to a fourteenth embodiment;

FIG. **52** is a view showing an outline of a in-field display controller of an operating microscope according to a fifteenth embodiment;

FIGS. **53**A and **53**B are views individually showing display states in the field of an operating microscope according to a sixteenth embodiment;

FIG. **54** is a general view of a surgical system using a rigid scope in combination with an operating microscope according to a seventeenth embodiment;

FIG. **55** is a detailed sectional view showing the construction of the rigid scope shown in FIG. **54**;

FIG. **56** is a general view of a surgical system using a rigid scope in combination with an operating microscope according to an eighteenth embodiment;

FIG. **57** is a detailed sectional view showing the construction of the rigid scope shown in FIG. **56**;

FIG. **58** is a view showing the configuration of the upper surface portion of a coupling portion of the rigid scope shown in FIG. **54**;

FIG. **59** is a general view of a surgical system using a rigid scope in combination with an operating microscope according to a ninth embodiment;

FIG. **60** is a detailed sectional view showing the construction of the rigid scope shown in FIG. **59**;

FIG. **61** is a view taken in the direction of arrow X of FIG. **60**;

FIG. **62** is a perspective view of an endoscopic surgical system according to a twentieth embodiment of the invention;

FIG. **63** is a sectional view of an instrument constituting the endoscopic surgical system of FIG. **62**;

FIG. **64** is a conceptual diagram for illustrating wire-type transmission means of the instrument;

FIG. **65** is a perspective view showing a first operation mode of the endoscopic surgical system of FIG. **62**;

FIG. **66** is a perspective view showing a second operation mode of the endoscopic surgical system of FIG. **62**;

FIG. **67** is a perspective view showing a modification of the endoscopic surgical system of FIG. **62**;

FIG. **68** is a perspective view of an endoscopic surgical system according to a twenty-first embodiment of the invention;

FIG. **69** is a sectional view of an instrument connecting member of the endoscopic surgical system of FIG. **68**;

FIG. **70** is a block diagram of an electric control system for the endoscopic surgical system of FIG. **68**;

FIG. **71** is a perspective view of an endoscopic surgical system according to a twenty-second embodiment of the invention;

FIGS. **72** and **73** are views showing a prior art endoscopic surgical system;

FIG. **74** is a schematic view showing a configuration of the principal part of a conventional operating microscope apparatus; and

FIGS. **75**A and **75**B are plan views individually showing in-field images displayed in operator and mate eyepiece units, respectively, of an operating microscope of the conventional operating microscope apparatus.

DETAILED DESCRIPTION OF THE INVENTION

First Embodiment

A first embodiment of the present invention will now be described in detail with reference to the accompanying drawings.

FIG. **1** shows an outline of an operating microscope for use as first observational means of a surgical observational system according to the present embodiment. FIG. **2** is a block diagram according to the present embodiment, and FIG. **3** shows a microscope body portion of the operating microscope in detail. Further, FIGS. **4**A, **4**B, **5**A and **5**B show the respective operations of first and second liquid crystal shutters, and FIGS. **6**A and **6**B individually show images observed by an operator. FIGS. **7**A and **7**B show an example of a display image on monitors **40** and **14**.

The surgical observational system according to the first embodiment will be described first.

The operating microscope of the surgical observational system according to the present embodiment is provided with a stand **21**, which includes a base **21***a* movable on a floor surface and a support post **21***b* set up on the base **21***a*. One end of a first arm **22**, which has a light source for illumination (not shown) therein, is mounted on the upper end portion of the post **21***b* so as to be rotatable around an axis Oa.

One end of a second arm **23** is attached to the other end of the first arm **22**, which is distant from the support post **21***b*, so as to be rotatable around an axis Ob. The second arm **23** is a pantograph arm that is formed of a link mechanism

and a balancing gas spring. The other end of the arm **23** that is off the first arm **22** can be moved vertically. A third arm **24** is attached to the other end of the second arm **23** so as to be rotatable around an axis Oc. Further, the third arm **24** is provided with a swing arm **25** that enables a microscope body **1** to swing in the anteroposterior direction along the direction of the operator's observation around an axis Od and swing in the lateral direction of the operator's body around an axis Oe. The microscope body **1**, an observational portion **2**, and a handle **26** are mounted on the distal end portion of the arm **25**.

In order to allow the microscope body **1** to be freely positioned in a three-dimensional space, moreover, each of the individual rocking portions that are rotatable around the axes Oa to Oe is provided with a electromagnetic brake. Each rocking portion can be locked and unlocked by means of a switch (not shown) that is provided on the handle **26**. Preferably, a power source unit for the electromagnetic brakes should be incorporated in the support post **21***b*.

As shown in FIG. **2**, the microscope body **1** is situated over an affected region P which is a portion or an area to be operated, and an index **3** for optical position detection is attached to a predetermined face of the microscope body **1**. The index **3** is fitted with a plurality of infrared LED's of the time-sharing emission type, which will not be described in detail.

Although the microscope body **1** has therein two observational optical systems for supplying luminous fluxes individually to the two eyes of the operator, only one of them will be described for simplicity.

As shown in FIG. **3**, an observational optical system **10** is composed of an objective lens **4**, first imaging lens **6**, lens **7**, second imaging lens **8**, and eyepiece **9**, which are arranged successively from the side of the affected region P. A half-mirror **11** is interposed between the lenses **7** and **8** of the optical system **10**. The half-mirror **11** is oriented so that it can reflect a luminous flux from a direction perpendicular to the optical axis of the observational optical system **10** toward the eyepiece **9**. A projection optical system **15** is composed of a lens **12**, third imaging lens **13**, and monitor **14**, which are arranged successively on an optical axis that extends at right angles to the optical axis of the optical system **10**.

Further, a first liquid crystal shutter **16** is located on the imaging point of the first imaging lens **6** of the observational optical system **10**, and a second liquid crystal shutter **17** on the imaging point of the third imaging lens **13** of the projection optical system **15**.

As previously described with reference to FIG. **2**, the microscope body **1** is fitted with the index **3** for optical position detection. An optical position detecting member **30** (hereinafter referred to as digitizer **30**) is provided in a required position in an operating room where it can shoot the index **3**.

The digitizer **30** includes a plurality of infrared cameras, which are mounted at given spaces. The digitizer **30** is connected to a position detector **31**. The detector **31** is connected to a computing unit **32**, which is connected with a mixer **33** and a liquid crystal driver **34**. Further, the unit **32** is connected with input means **35** and a footswitch **36**. The switch **36** is provided with an image on-off switch (not shown).

As shown in FIG. **3**, the liquid crystal driver **34** is connected to the first and second liquid crystal shutters **16** and **17** in the microscope body **1**. The mixer **33** is connected to the monitor **14** in the microscope body **1**.

In FIG. **2**, numeral **37** denotes an ultrasonic probe that is inserted in the affected region P. The probe **37** is fitted with an index **38** that resembles the one on the microscope body **1**. The index **38** is also fitted with a plurality of infrared LED's of the time-sharing emission type, which will not be described in detail. However, the time-sharing emission patterns of the infrared LED's that are attached to the index **38** are different from those of the ones attached to the index **3**. The position detector **31** can detect the respective positions of the patterns separately.

The ultrasonic probe **37** is connected to an ultrasonic observer **39**. A video output (not shown) from the observer **39** is connected to the monitor **40** and the mixer **33**.

Referring now to FIGS. **1** to **7**B, there will be described the operation of the surgical observational system according to the first embodiment.

A luminous flux emitted from the light source (not shown) in the first arm **22** is applied to the affected region P of a patient's body through an optical fiber (not shown) and an illumination optical system (not shown). As shown in FIG. **3**, the luminous flux reflected by the affected region P lands on the objective lens **4** of the microscope body **1**, is focused through the first imaging lens **6**, first liquid crystal shutter **16**, lens **7**, half-mirror **11**, and second imaging lens **8**, and is subjected to enlarged-scale observation through the eyepiece **9** by the operator. In this state, the whole surface of the first liquid crystal shutter **16** is transmittable, as shown in FIG. **4**A. FIG. **6**A shows the image that is observed by the operator in this state. This process will be mentioned later.

On the other hand, the ultrasonic probe **37** to be inserted into the affected region P may be formed of a conventional ultrasonic probe that emits an ultrasound from a rotating portion (not shown) on its distal end. The ultrasound reflected by the affected region P is received by a sensor (not shown), and a signal from the sensor is transmitted to the ultrasonic observer **39**. The observer **39** analyzes the signal from the ultrasonic probe **37** and generates an image-processed video signal that is indicative of the internal structure of the tissue in accordance with the attenuation or phase of the ultrasound based on the rotational angle of the rotating portion (not shown). Then, the video signal is delivered to the monitor **40** to be displayed thereon. FIG. **7**A shows the image then displayed on the monitor **40**. The same video signal that is delivered to the monitor **40** is also delivered to the mixer **33**.

Further, the index **3** that is attached to the microscope body **1** causes the infrared LED's (not shown) to glow in a given time-sharing pattern. Likewise, the index **38** that is attached to the ultrasonic probe **37** causes the infrared LED's (not shown) to glow in a time-sharing pattern different from the pattern for the index **3**.

The respective states of light emission of the indexes **3** and **38** are shot by means of the infrared cameras (not shown) of the digitizer **30**. The information obtained by means of the digitizer **30** is analyzed by means of the position detector **31**, whereupon the respective positions and attitudes of the microscope body **1** and the ultrasonic probe **37** in the three-dimensional space are detected. A conventional suitable technique can be used for this optical position detection system.

Since the affected region P is also positioned in the three-dimensional space, moreover, the position detector **31** can detect the relative positions of the affected region P, microscope body **1** (observational position of the operating microscope), and ultrasonic probe **37** (plane for ultrasonic observation).

As shown in FIG. **2**, the position information detected by means of the position detector **31** is delivered to the computing unit **32**.

If the image on-off switch (not shown) of the footswitch **36** is then off, the computing unit **32** delivers an image-off signal to the mixer **33** and the liquid crystal driver **34**. The mixer **33** outputs no image when it receives the image-off signal from the computing unit **32**. Therefore, no image is displayed on the monitor **14** that is connected to the mixer **33**. On receiving the image-off signal from the computing unit **32**, moreover, the liquid crystal driver **34** delivers given outputs to the first and second liquid crystal shutters **16** and **17**. Thereupon, the whole surface of the first liquid crystal shutter **16** becomes transmittable, as shown in FIG. **4**A. Further, the second liquid crystal shutter **17** is rendered entirely interceptive, as shown in FIG. **5**A. Thus, the operator can obtain no image from the monitor **1**, only observing the optical image of the affected region P. FIG. **6**A shows this state of observation.

If the operator then turns on the image on-off switch of the footswitch **36**, an image-on signal is delivered to the computing unit **32**. In this state, the computing unit **32** computes the position of the distal end of the ultrasonic probe **37** in the field of observation of the operating microscope on the basis of the detected information from the position detector **31**. Further, the respective positions of the monitor **14** and the first and second liquid crystal shutters **16** and **17** corresponding to the distal end position are computed.

Then, the computing unit **32** calculates a signal from the input means **35** and settles the size of an image in the microscopic field. The operator can freely change the image size by operating the input means **35**.

Based on the result of the aforesaid computation and the signal from the input means **35**, the computing unit **32** delivers a control signal to the mixer **33**. The mixer **33** converts the output image of the ultrasonic observer **39** into an image that has its center in a position corresponding to the distal end position of the ultrasonic probe **37** of the monitor **14**, and further generates an image signal of a reduced size set by means of the input means **35**. FIG. **7**B shows this image signal.

Then, the computing unit **32** delivers a control signal to the liquid crystal driver **34**. The driver **34** generates, on the first and second liquid crystal shutters **16** and **17**, a shielding portion **41** (first liquid crystal shutter **16**) and a transparent portion **42** (second liquid crystal shutter **17**) that have positions and sizes corresponding to the range of the reduced image that is generated by means of the mixer **33**. This state is shown in FIG. **4**B (for the first liquid crystal shutter **16**) and FIG. **5**B (for the second liquid crystal shutter **17**).

In this arrangement, only that portion of the optical observational image from the objective lens **4** which corresponds to the shielding portion **41** is intercepted by means of the first liquid crystal shutter **16**, and only the reduced image portion of the monitor **14** is transmitted to the side of the half-mirror **11** through the transparent portion **42** of the second liquid crystal shutter **17**.

Thus, the operator can observe superposed ultrasonic images on the monitor **14** in a predetermined range centering around the distal end of the ultrasonic probe **37**, among other microscopic images. If the operator moves the probe **37** within the microscopic field, the ultrasonic images also move correspondingly in the field. FIG. **6**B shows this state of observation.

If the operator operates again the image on-off switch (not shown) of the footswitch **36**, the ultrasonic images disappear in a moment, and the state of observation shown in FIG. **6**A is restored.

Thus, the surgical observational system according to the first embodiment can produce the following effects.

According to the first embodiment, the operator can observe the optical observational image and ultrasonic diagnostic images in a superposed manner, and the optical observational image is superposed only partially. Therefore, the diagnostic images and the affected region can be easily correlated, and transfer to each treatment can be effected smoothly. Since the images follow the ultrasonic probe, moreover, the operator can observe a desired region without delay. In consequence, the operation time can be shortened, and the operator's fatigue can be eased.

Second Embodiment

A second embodiment of the present invention will now be described with reference to FIGS. **8** to **10**C.

In these drawings, like reference numerals refer to the same portions of the first embodiment, and a description of those portions is omitted.

FIG. **8** is a block diagram according to the present embodiment, FIG. **9** shows the body of the operating microscope in detail, and FIGS. **10**A to **10**C individually show varied states of images the operator observes.

A surgical observational system according to the second embodiment will be described first.

In the second embodiment, as shown in FIG. **9**, a variable-scale optical system **50** is interposed between an objective lens **4** and a first imaging lens **6** of a microscope body **1**. A lens drive section (not shown) of the optical system **50** is provided with a sensor (not shown), which is connected to magnification detecting means **56**. As shown in FIG. **8**, the detecting means **56** is connected to a computing unit **55**.

A changeover switch (not shown) of a footswitch **57**, which is connected to the computing unit **55**, is connected to a position detector **54**. As in the case of the first embodiment, the output of a digitizer **30** is connected to the position detector **54**. The position detector **54** includes an image forming section (not shown), the image output of which is connected to a monitor **53** in the microscope body **1**. A fourth imaging lens **52** and a mirror **51** are arranged successively on the emission side of the monitor **53**. The imaging position of the fourth imaging lens **52** is substantially aligned with the reflective surface of the mirror **51** and the imaging plane of a second imaging lens **8**. Accordingly, the operator can simultaneously observe, through an eyepiece **9**, a microscopic optical image formed by means of the first imaging lens **6** and an image on the monitor **53** formed by means of the fourth imaging lens **52**.

The following is a description of the operation of the surgical observational system according to the second embodiment.

As in the case of the first embodiment, the position detector **54** can detect the respective positions of the point of microscope observation and the distal end of an ultrasonic probe **37** relative to the affected region P. Further, the detector **54** stores preoperative diagnostic images (e.g., slice images of an X-ray CT apparatus; normally, slice images in a given direction and a three-dimensional CG image constructed by joining the slice images) in its storage section (not shown). In starting observation of the ultrasonic images in the microscopic field, the operator turns on an image on-off switch (not shown) of the footswitch **57**. As this is done, a signal from the sensor (not shown) of the variable-scale optical system **50** is transmitted to the magnification detecting means **56**. The detecting means **56** calculates the

observation magnification of the microscope and delivers it to the computing unit **55**.

Based on data from the magnification detecting means **56**, the computing unit **55** sets the display size of an ultrasonic image to be projected in the microscopic field. FIG. **10**A shows the state of the image the operator then observes.

If the operator operates the changeover switch (not shown) of the footswitch **57** in this state, moreover, the position detector **54** reads a preoperative diagnostic slice image corresponding to the position of the distal end portion of the ultrasonic probe **37** from the storage section (not shown). Then, the detector **54** superposes a marker on a region where the ultrasonic probe **37** is situated, and delivers the resulting image to the monitor **53**. AS this is done, the mirror **51** moves from an evacuation position (not shown) to an observational position shown in FIG. **9**, whereupon the operator can observe the image on the monitor **53** along with a microscopic image through the mirror **51**.

When the operator depresses the changeover switch (not shown) once, a preoperative diagnostic slice image, such as the one shown in FIG. **10**B, is displayed. In this state, the operator can observe the actual affected region and the ultrasonic diagnostic image in association with the preoperative diagnostic slice image (with the display of the ultrasonic probe position).

If the operator depresses the changeover switch once again, the position detector **54** reads the three-dimensional image of the affected region P from the storage section (not shown), and carries out rotation processing (image processing) of the three-dimensional image so that the image is aligned with the direction of actual insertion of the ultrasonic probe **37** into the affected region. Then, the detector **54** superposes the marker on the region and along the direction in which the probe **37** is situated, and delivers the resulting image to the monitor **53**. FIG. **10**C shows the image the operator then observes. In this state, the operator can observe the actual affected region and the ultrasonic diagnostic image in association with the three-dimensional preoperative diagnostic image (with the display of the ultrasonic probe position and direction).

If the operator depresses the changeover switch once again, the mirror **51** moves to the aforesaid evacuation position (not shown), whereupon the operator can observes the image shown in FIG. **10**A.

The surgical observational system according to the second embodiment can produce the following effects.

According to the second embodiment, which enjoys the same effects of the first embodiment, the display size of the ultrasonic image can be set automatically according to the observation magnification of the operating microscope. Therefore, the operator can be saved the trouble of setting the image size, so that the efficiency of surgical operations can be improved. Further, the operator can observe the preoperative diagnostic image simultaneously with the optical observational image and ultrasonic diagnostic image. Accordingly, the approximate position of the whole patient's body in the position for ultrasonic observation can be recognized with ease. Besides, the deviation between the actual affected region and the preoperative diagnostic image, which is attributable to change of the intracranial pressure after craniotomy or exclusion of tissue, can be recognized easily. Thus, accurate surgical operations can be carried out, and the results of operations can be improved.

Although the ultrasonic diagnostic image is displayed substantially in a circular form on the monitor **14** according to the second embodiment, its shape may be changed in the following manner.

In the case of an ultrasonic probe of the same radial-scan type (in which the periphery of the probe is scanned in a circle) as in the foregoing embodiment, as shown in FIG. **11**A, the central portion of the ultrasonic probe **37** may be extracted by means of the mixer **33** as it is displayed. The range of extraction is restricted to a radius that ranges from the distal end of the ultrasonic probe to the inner wall of the tissue of the affected region that is located closest to the probe. This range can be settled by analyzing the ultrasonic image or by means of an optical position detector. FIG. **11**B shows an actual image then observed by the operator.

According to this arrangement, a microscopic optical image is displayed in a range without any object of diagnosis, extending from the ultrasonic probe to the inner wall of the tissue of the affected region, and the region to be diagnosed can be displayed securely. Accordingly, the diagnosis can be carried out in the same manner as in the second embodiment, and the distal end of the ultrasonic probe never fails to be recognized on the optical observational image. Thus, the operator can move the ultrasonic probe without switching off the display of the ultrasonic image, so that the efficiency of surgical operations can be improved.

Third Embodiment

A third embodiment of the present invention will now be described with reference to FIGS. **12** to **15**D. In these drawings, like reference numerals refer to the same portions of the first and second embodiments, and a description of those portions is omitted.

FIG. **12** is a general block diagram illustrating the present embodiment, and FIG. **13** shows an observational image of a rigid scope for use as second observational means according to the present embodiment. FIGS. **14**A to **14**F illustrate the respective operations of first and second liquid crystal shutters according to the present embodiment, and FIGS. **15**A to **15**D show images observed by the operator according to the present embodiment.

A surgical observational system according to the third embodiment will be described first.

Numeral **1** denotes a body of an operating microscope that resembles the one according to the first embodiment. The microscope body **1**, like the one according to the first embodiment, is fitted with an index **3**. AS in the case of the second embodiment, a variable-scale optical system (not shown) of the microscope body **1** is provided with a sensor (not shown), which is connected to magnification detecting means **56**. As in the cases of the first and second embodiments, moreover, the microscope body **1** is provided with first and second liquid crystal shutters (not shown), which are connected to a liquid crystal driver **34**. The microscope body **1** is provided with a monitor (not shown) that resembles the one according to the first embodiment. The monitor is connected to a mixer **33**. Thus, the optical system in the microscope body **1** of the present embodiment is constructed substantially in the same manner as the one according to the first embodiment.

Numeral **90** denotes a 90°-squint rigid scope for use as second observational means according to the present embodiment. The rigid scope **90** is connected with one end of a light guide **91**, the other end of which is connected to a light source **92**. The rigid scope **90** is fitted with a camera head **93** for picking up its observational image. The camera head **93** is connected to a camera control unit **94** (hereinafter referred to simply as CCU **94**). A first video output section (not shown) of the CCU **94** is connected to a monitor **95**. A second video output section (not shown) of the CCU **94** is

connected to the mixer **33**. Further, an index **96** for position detection is attached to given position on the camera head **93**.

A digitizer **30** is located in a position such that it can shoot both the indexes **3** and **96** that are attached to the microscope body **1** and the camera head **93**, respectively. The digitizer **30** is connected to a position detector **31**. The detector **31** is connected to a computing unit **97**. Further, the magnification detecting means **56** and a footswitch **81** are connected to the computing unit **97**.

Furthermore, the computing unit **97** is connected to the mixer **33** and the liquid crystal driver **34**.

The following is a description of the operation of the third embodiment.

As in the case of the first embodiment, the operator subjects the affected region P to enlarged-scale stereoscopic optical observation by using the microscope body **1**. Further, the operator uses the rigid scope **90** to observe outside portions as viewed through the microscope body **1** for the optical observation. More specifically, a luminous flux for observation emitted from the light source **92** is landed on the light guide **91**. The light guide **91** transmits the incident luminous flux to the rigid scope **90** that is connected to the other end thereof. This luminous flux is applied to the affected region P through an illumination optical system (not shown) in the rigid scope **90**. The luminous flux reflected by the affected region P is landed on an objective lens (not shown) of the rigid scope **90** and focused on an image-pickup device (not shown) of the camera head **93** that is connected to the rear end of the scope **90**. The camera head **93** converts the luminous flux, focused on the image-pickup device, into an electrical signal, and delivers it to the CCU **94**. The CCU **94** converts the electrical signal into a standardized video signal, and delivers it through its first and second video output sections (not shown).

Thus, the image shot by means of the rigid scope **90** is displayed on the monitor **95** that is connected to the first video output section of the CCU **94**, as shown in FIG. **13**. The same video signal is delivered from the second video output section of the CCU **94** to the mixer **33** in like manner.

Infrared cameras (not shown) of the digitizer **30** are used to shoot infrared LED's (not shown) of the indexes **3** and **96** that are attached to the microscope body **1** and the camera head **93** of the rigid scope **90**, respectively. As in the case of the first embodiment, the information obtained by means of the digitizer **30** is analyzed by means of the position detector **31**, whereupon the respective positions and attitudes of the microscope body **1** and the rigid scope **90** in the three-dimensional space are detected. Since the affected region P is also positioned in the three-dimensional space, moreover, the position detector **31** can detect the position of the affected region P relatively to the respective observational positions and directions of the microscope body **1** and the rigid scope **90**.

The position information detected by means of the position detector **31** is delivered to the computing unit **97**.

FIG. **15**A shows an image then observed by the operator. The operator observes only an optical image that is obtained by means of the body **1** of the operating microscope. In this state, the first liquid crystal shutter (not shown) in the microscope body **1** is fully transmittable, while the second liquid crystal shutter (not shown) is entirely interceptive. An image then obtained by means of the rigid scope **90** is displayed on the monitor **95**.

In starting observation of the image obtained by means of the rigid scope **90** in the microscopic field, the operator turns on an image on-off switch (not shown) of the footswitch **81**. The resulting signal is transmitted to the computing unit **97**. On receiving an image-on signal from the footswitch **81**, the computing unit **97** first carries out computation to display the image in a given position in the microscopic field (upper left portion of the microscopic field according to the present embodiment) and delivers command signals to the liquid crystal driver **34** and the mixer **33**. More specifically, a signal is delivered to the liquid crystal driver **34** such that it controls the first and second liquid crystal shutters for the states shown in FIG. **14**A and **14**B, respectively. Further, a signal is delivered to the mixer **33** such that the video signal from the CCU **94** is reduced at a suitable scale factor computed on the basis of a signal from the magnification detecting means **56** and that the image is moved to a region corresponding to a shielding portion of the second liquid crystal shutter and displayed on the monitor (not shown) in the microscope body **1** in the manner shown in FIG. **14**C. FIG. **15**B shows the state of the image then observed by the operator. In this state, the operator roughly positions the rigid scope **90** while comparing the distal end of the rigid scope **90** and the affected region.

Then, in displaying the microscopic field and the field of the rigid scope **90** in association with each other, the operator turns on an image shift switch (not shown) of the footswitch **81**. The resulting signal is applied to the computing unit **97**. On receiving this signal, the computing unit **97** computes the position of display of the image of the rigid scope **90** in the microscopic field in accordance with position information from the position detector **31** and magnification information on the microscope body **1** from the magnification detecting means **56**. Thus, the range of the microscopic field is calculated from the position and magnification of the body **1** of the microscope, while the distal end position and observational direction of the rigid scope **90** in the microscopic field is calculated from the position information of the scope **90**. Based on the results of these calculations, the computing unit **97** delivers a command signal to display the image of the rigid scope **90** in a circular range that has its center on the observational-direction side of the rigid scope **90** with its distal end on a point on the diameter of the circle. More specifically, the first and second liquid crystal shutters are set for the states shown in FIGS. **14**D and **14**E, respectively, and the monitor (not shown) in the microscope body **1** displays the image shown in FIG. **14**F. Thus, the operator can obtain the field shown in FIG. **15**B in the microscopic field. Since the rigid scope **90** is 90°-squint, moreover, the observational direction changes if it is rotated for 90° in its axial direction, for example. In this state also, the image of the rigid scope **90** is displayed in a circular range that has its center on the observational-direction side of the rigid scope **90** with its distal end on a point on the diameter of the circle, so that the field shown in FIG. **15**D can be obtained.

According to this third embodiment, the second observational means, e.g., the rigid scope or an ultrasonic observation apparatus of the front-scan type, can be effectively used in particular when an object is observed in a given direction from the distal end of the probe, and the observational image is displayed in the observational direction of the probe. Accordingly, the observational direction and position of the second observational means can be grasped with ease, and besides, the optical image of the actual affected region and the image obtained by means of the second observational means are positioned in association with each other as they are displayed. Thus, the state of the affected region can be grasped quickly and accurately.

Although the second observational means has been described as means for observing a narrower range than the operating microscope or first observational means does, in connection with the second and third embodiments, the present invention is not limited to this arrangement. If an image of a wide range that includes the affected region is obtained by means of an X-ray CT apparatus or the like, for example, a part of the image may be cut out and projected in the microscopic field in like manner provided that the positional relations between the image, the actual affected region, and the position of the body of the microscope can be grasped. According to each of the foregoing embodiments, the image is displayed following the distal end of each probe. In the case of a wide-range image such as the aforesaid X-ray CT image, however, a cursor may be displayed in the microscopic field so that the operator can move it by means of the footswitch or the like, thereby causing the cut image to follow the cursor. Thus, the operator can observe only a desired portion of the X-ray CT image to be referred to, in association with the affected region, so that the effects of the present invention can be accomplished.

Although the operating microscope is used as the first observational means and the image of the second observational means is superposed on the microscopic optical image according to the first to third embodiments, the present invention is not limited to this arrangement. It is to be understood that quite the same effects can be produced if the display image of the first observational means is a TV monitor.

Fourth Embodiment

A fourth embodiment of the present invention will now be described. The following is a description of a configuration of a fluorescent image observation apparatus of an operating microscope with position detecting means that can detect the position of an affected region.

FIG. **16** shows a configuration of the operating microscope with the position detecting means that can detect the affected region position. This configuration will be briefly described herein, since it is described in Jpn. Pat. Appln. No. 10-319190 filed by the assignee of the present invention. Numeral **101** denotes the operating microscope, which comprises a microscope body **102** that constitutes an observational optical system through which an operator **108** can observe an affected region of a patient **107**. The microscope body **102** is provided with an emissive index **103**.

Numeral **104** denotes a digitizer **104**, which includes two CCD cameras **105***a* and **105***b* for use as receivers and a camera support member **106** for supporting these cameras. The digitizer **104** serves as optical position detecting means that uses the CCD cameras **105***a* and **105***b* to detect the emissive index **103** of the microscope body **102**, thereby detecting the observational position of the microscope.

FIG. **17** shows a configuration of an illumination system of the operating microscope **101**, and FIG. **18** shows a configuration of the observational optical system of the microscope **101**. FIG. **17** is a diagram as viewed from a position A of FIG. **18**.

The illumination system shown in FIG. **17** comprises a light source **109**, condensing lens **110**, illumination lens **112**, and beam splitter **113**. The members **110**, **112** and **113** serve to guide illumination light emitted from the light source **109** to the affected region P of the patient **107**.

An illumination light switching filter **111** includes an illumination light transmitting filter **111***a* for transmitting illumination light for the affected region P, an excitation light transmitting filter **111***b* for transmitting only excitation light that is inductive to fluorescence, and a drive motor **111***c* for use as a switching mechanism for changing these two filters. Thus, the filter **111** serves as illumination light switching means for the affected region P. Further, an objective lens **114**, zoom optical systems **115**L and **115**R, and beam splitters **116**L and **116**R are provided for the observation of light reflected by the affected region P.

The observational optical system shown in FIG. **18** comprises the beam splitters **116**L and **116**R and eyepieces **117**L and **117**R, as well as the zoom optical systems **115**L and **115**R. An image from the affected region P is transmitted through the beam splitter **116**L to a lens **118**L, a mirror **120**L, and an image-pickup device **121**L, which constitute a shooting system.

An observational light switching filter **119**L includes an illumination light transmitting filter **119L1** for transmitting the illumination light for the affected region P, a cutoff filter **119L2** for cutting off the excitation light and illumination light, and a drive motor **119L3** for use as a switching mechanism for changing these two filters. Thus, the filter **119**L serves as observational light switching means for the affected region P.

FIG. **19** is a general functional block diagram of the operating microscope **101**. In FIG. **19**, the motors **111***c* and **119L3** are connected to a filter drive controller **123**, which can control these motors simultaneously, in response to a signal from an input switch (display mode setting means) **122** for fluorescent image observation. The filter drive controller **123** serves to control the motors **111***c* and **119L3** so that the illumination light transmitting filter **111***a* of the illumination light switching filter **111** and the illumination light transmitting filter **119L1** of the observational light switching filter **119**L are simultaneously situated on the optical axis. The controller **123** also serves to control the motors **111***c* and **119L3** so that the excitation light transmitting filter **111***b* of the illumination light switching filter **111** and the cutoff filter **119L2** of the observational light switching filter **119**L are simultaneously situated on the optical axis. Under this control, the operation mode can be changed from a fixed-time fluorescent observation mode to a normal (visible zone) observation mode by means of a timer circuit (not shown).

Further, the image-pickup device **121**L is connected to a video signal processor **128**. The device **121**L is composed of a drive processor circuit (not shown) and a video signal generator circuit (not shown). A memory (storage means) **129**, which can operate in response to a signal from the input switch **122**, is composed of an image memory and a binary coder circuit (not shown) for binary-coding a video signal delivered from the video signal processor **128**.

Furthermore, a workstation (hereinafter referred to as WS) **125** is connected with a microscope body controller **126**, digitizer **124**, monitor **127**, and mixer **130**. The controller **126** can detect and transmit information data such as the magnification, focal length, etc. of the operating microscope **101** that is provided with the emissive index **103**. The digitizer **124** can detect the position of the affected region P by detecting the index **103**. If the magnification and focus information data are changed, they are transmitted from the controller **126** to the WS **125**. Thereupon, the WS **125** selects a preoperative image corresponding to the operating position in consideration of the transmitted data and position information from the digitizer **124**. The digitizer **124** and the WS **125** constitute position computing means.

The mixer **130**, which is connected to the WS **125**, video signal processor **128**, and memory **129**, serves to superpose video signals that are transmitted individually from the WS **125**, processor **128**, and memory **129**, and can display the superposed video signals on a monitor **131** outside the microscope body. The mixer **130** and the monitor **131** constitute display means.

In the arrangement described above, the observational position of the operating microscope is detected by detecting the emissive index **103** on the microscope by means of the digitizer **124** and computing the positional relation between the microscope and the detected index **103** by means of the WS **125**. By doing this, the correlation with a two-dimensional preoperative tomographic image as a diagnostic image of the patient's body stored in the WS **125** can be obtained (the apparatus of this type is called a navigation apparatus).

FIG. **20** is a flowchart for illustrating the operation of the present invention. Since a method for simultaneously shooting the image based on the illumination light and the fluorescent image is described in detail in Jpn. Pat. Appln. KOKAI Publication No. 9-24052, only features of the present invention will be described in the following.

If the input switch **122** for fluorescent image observation is turned on (A1), the filter drive controller **123** controls the motors **111***c* and **119L3** (A2-1) to locate the excitation light transmitting filter **111***b* of the illumination light switching filter **111** and the cutoff filter **119L2** of the observational light switching filter **119**L simultaneously on the optical axis.

Fluorescent shooting (A3-1) is carried out in this state. Light transmitted through the excitation light transmitting filter **111***b* of the illumination light switching filter **111** is applied to the affected region P, thereby inducing fluorescence. The illumination light and the excitation light is cut off by means of the cutoff filter **119L2** of the observational light switching filter **119**L, and only the detected fluorescent image induced by the affected region P is reflected by the mirror **120**L and landed on the image-pickup device **121**L.

The detected fluorescent image incident upon the image-pickup device **121**L is converted into a video signal by means of the video signal processor **128** and applied to the memory **129** and the mixer **130**. The video signal that is applied to the memory **129** is binary-coded (A4). Thereafter, it is applied to the mixer **130** and displayed as a fluorescent observational image on the monitor **131**.

If the motors **111***c* and **119L3** are controlled by means of the filter drive controller **123** so that the illumination light transmitting filter **111***a* of the illumination light switching filter **111** and the illumination light transmitting filter **119L1** of the observational light switching filter **119**L are located simultaneously on the optical axis, the illumination light is applied to the affected region P, and an image of the affected region is landed on the image-pickup device **121**L. This illumination light is processed by means of the video signal processor **128** and applied to the mixer **130**.

AS this is done, a two-dimensional preoperative image that matches the observational position information (A2-2) on the affected region P obtained according to the emissive index **103**, which is detected by means of the digitizer **124**, and the magnification and focus information data on the operating microscope **101**, which are transmitted from the microscope body controller **126** to the WS **125**, is selected from ones that are previously recorded in the WS **125** (A3-2) and applied to the mixer **130**.

The mixer **130** synthesizes (superposes) the video image based on the illumination light form the video signal processor **128**, the fluorescent image binary-coded by means of the memory **129**, and the preoperative image selected and inputted by means of the WS **125** (A5).

In these circumstances, the filter drive controller **123** selects the illumination light transmitting filter **111***a* and the illumination light transmitting filter **119L1** on illumination and shooting light paths, respectively. The image-pickup device **121**L shoots an image in a normal or visible zone. A tumor position obtained by the aforesaid fluorescent observation and a tumor position based on the two-dimensional preoperative tomographic image selected by means of the WS **125** are superposed on the image of the affected region presently obtained by the operator and are displayed on the monitor **131**.

FIG. **21** is a diagram for illustrating the way of synthesizing the fluorescent observational image and the two-dimensional preoperative tomographic image.

In an entire tumor image **142** as an affected region in an entire head image **141** of FIG. **21**, a plane image (fluorescent observational image) **145***a*, based on a fluorescent image obtained from a certain curved surface in a surgical treatment position (exposed tumor portion **144**), and a two-dimensional preoperative tomographic image **145***b*, selected as a microscopic observational position by the WS **125**, can be synthesized and displayed on the monitor **131**.

If the operator then moves the focal center position from B to C by focusing operation, the center of observation (center of the depth of focus) can be detected by means of the digitizer **124** and the WS **125** so that a corresponding tomographic image can be selected and synthesized with the aforesaid fluorescent observational image. In terminating the fluorescent observation, the operator is expected to turn off the input switch **122**, thereby switching off the superposed display.

The fourth embodiment described above enjoys the following effects. Since an actual affected region has no flat surface, display of only a tomographic image as a diagnostic image in the microscopic observational position can hardly cover the state of the affected region. With use of the arrangement of the present embodiment, however, tomographic images based on the focusing operation for the present treatment position are superposed on the fluorescent observational image as they are displayed, so that the progress of a surgical operation and the conditions of a tumor can be recognized visually.

Further, the fluorescent observational image is superposed on the two-dimensional preoperative tomographic image as it is displayed. If the surgical operation is advanced according to the preoperative tomographic image, therefore, the operator can recognize supplementary correction of the position according to the fluorescent observational image during the operation. Thus, the correction is easy.

Since the mode for the superposed observation can be set by the input switch operation, moreover, the superposed observation can be selectively carried out as required. If only the external shape of the tumor portion is expected to be emphasized in the tomographic image from the WS, the operator can easily discriminate it by making its display color different from that of the fluorescent observational image.

Fifth Embodiment

FIGS. **22** and **23** show a configuration according to a fifth embodiment. Since left- and right-hand observational images of an affected region are processed in the same manner, the way of processing the left-hand observational image will now be described representatively.

AS in the case of the fourth embodiment, illumination or excitation light is applied to the affected region, and an image of the affected region is obtained by means of an image-pickup device **121**L. The device **121**L is connected to a video signal processor **135**L for converting an image into a video signal. An output signal from the processor **135**L is applied to a left-hand memory **136**L. The memory **136**L serves to binary-code the image, and its signal is applied to a left-hand mixer **137**L that can superpose a plurality of video images. Output signals from the left-hand mixer **137**L and a right-hand mixer **137**R are applied to a **3**D converter **139** to be converted into a three-dimensional video image thereby, whereupon the video image can be displayed on a **3**D monitor **140**.

Further, output signals from the left-hand video signal processor **135**L and a right-hand video signal processor **135**R are applied to the **3**D converter **139** to be converted into a three-dimensional video image thereby, and the image can be displayed on the **3**D monitor **140**.

The WS **125** can apply the three-dimensional video image to bilateral screen dividing means **138**, which can divide the three-dimensional video image into images with a lateral parallax. A left-hand video image is generated and applied to the left-hand mixer **137**L. The mixer **137**L is connected to a left-hand monitor **134**L. Further, a lens **133**L and a beam splitter **132**L are arranged in order to guide the video image on the monitor **134**L to the eyepiece **117**L (see FIG. **22**).

With the arrangement described above, fluorescence is excited, and the resulting fluorescent image is delivered to left- and right-hand image-pickup devices **121**L and **121**R, as in the case of the fourth embodiment. Since video images applied to the image-pickup devices **121**L and **121**R are processed in the same manner, only the processing on the left-hand side will now be described. The fluorescent image obtained by means of the image-pickup device **121**L is applied to the left-hand video signal processor **135**L to be converted into a video signal thereby, and applied to the left-hand memory **136**L and the **3**D converter **139**.

In order to divide stereoscopic image information, based on the preoperative tomographic image information recorded in the WS **125**, into images with a lateral parallax, moreover, the preoperative tomographic image is applied to the bilateral screen dividing means **138**. In the left-hand mixer **137**L, a left-hand image produced by the dividing means **138** is superposed on the signal from the left-hand memory **136**L that binary-codes the signal from the left-hand video signal processor **135**L.

A synthetic image delivered from the left-hand mixer **137**L is applied to the **3**D converter **139** and the left-hand monitor **134**L. The converter **139** can convert the video image from the left- and right-hand mixers **137**L and **137**R into a three-dimensional image and display the image on the **3**D monitor **140**.

The light applied to the left-hand monitor **134**L is guided to the eyepiece **117**L via the lens **133**L and the beam splitter **132**L.

In this manner, the observational image of the affected region P based on the illumination light, the fluorescent observational image based on the application of the excitation light to the affected region, and the three-dimensional image based on the preoperative image can be simultaneously cast into the operator's field of vision and displayed on the **3**D monitor **140**. In this case, the present treated section information based on the fluorescent observational image is superposed three-dimensionally on a three-dimensional exterior view of a tumor (three-dimensional tumor image **147**), such as the one shown in FIG. **25**, so that the present progress of operation for the whole tumor can be recognized. In FIG. **25**, the outline is formed by a position detecting function, and broken lines represent a stereoscopic affected region image based on the fluorescent observational image.

According to the fifth embodiment described above, the optical observational images obtained by microscopic observation are superposed, so that the present treatment position and progress of the affected region P in the whole tumor can be grasped three-dimensionally, and the direction of the treatment to be advanced thereafter can be recognized accurately. Dislocation of the preoperative tomographic image from the entire external shape can be also recognized, and it can be minutely corrected by stereoscopic observation. Thus, an environment can be provided for high-safety surgical operations.

Sixth Embodiment

The following is a description of only differences of a sixth embodiment of the present invention from the fifth embodiment. FIG. **24** is a diagram showing a configuration of the sixth embodiment. An image signal based on illumination light incident upon a left-hand video signal processor **135**L is applied to a left-hand mixer **137**L. In the sixth embodiment, the mixer **137**L is connected to a left-hand in-field display controller **148**L. The controller **148**L is constructed in the same manner as an in-field display controller that constitutes an in-field display device (in-field display controller and lens tube portion) described with reference to FIG. **1** in Jpn. Pat. Appln. No. 10-248672. According to the sixth embodiment, the display according to the fifth embodiment is indicated and observed as an image display separate from the microscopic field.

In the arrangement described above, the image signal based on the illumination light incident upon the left-hand video signal processor **135**L is applied to the left-hand mixer **137**L. In the mixer **137**L, a microscopic image based on the illumination light, a fluorescent image based on excitation light, and a preoperative image selected according to the outer peripheral surface of an affected region are synthesized and applied to the left-hand in-field display controller **148**L. The video image applied to the controller **148**L is displayed as an in-field display image by means of the in-field display device, and only an image based on the illumination light is visible as the microscopic image.

The sixth embodiment described above has the following effects as well as the effects of the fifth embodiments. In the microscopic image based on the illumination light, as shown in FIG. **26**, an exposed tumor portion **151** that cannot be recognized by the operator can be identified by being compared with the superposed in-field display image. Further, the three-dimensional shape of a tumor and the position of an affected region in the whole tumor can be grasped without screening a microscopic image **150** with the preoperative image and the fluorescent observational image.

Seventh Embodiment

A seventh embodiment of the present invention will now be described with reference to FIGS. **27** to **35**B. FIG. **27** shows the general external appearance of an operating microscope **201** of an operating microscope apparatus according to the present embodiment. A stand **202** of the operating microscope **201** of the present embodiment is provided with a base **203** movable on a floor surface and a support post **204** set up on the base **203**.

Further, the support post **204** is provided, on its top portion, with a body **205** of the operating microscope **201**, including an optical system for observing an affected region, and a support mechanism **206** for supporting the body **205** for movement in any desired direction. The mechanism **206** is a combination of a plurality of moving arms **207** for locating the microscope body **205** in a desired position.

As shown in FIG. **28**, moreover, the body **205** of the operating microscope **201** of the present embodiment is provided with an operator eyepiece unit **208** and a mate eyepiece unit **209**. The body **205** is also provided with a barrel **210** for rotatably holding the mate eyepiece unit **209**. The eyepiece unit **209** can be rotated with respect to the operator eyepiece unit **208** by means of the barrel **210**.

Located near the barrel **210**, moreover, is a position detecting encoder **211** that detects the rotational angle of the mate eyepiece unit **209** with respect to the operator eyepiece unit **208** and outputs it as an electrical signal.

FIG. **29** is a schematic view of an optical system of the body **205** of the operating microscope **201**, and FIG. **30** is a block diagram of an electric circuit of the microscope **201**. As shown in FIG. **29**, the optical system of the body **205** of the operating microscope **201** according to the present embodiment is provided with a beam splitter **212** for dividing a microscopic image (incident light) into two parts for an operator-side optical system La and a mate-side optical system Lb. The light incident upon the beam splitter **212** is divided into two light beams, transmitted and reflected. The transmitted and reflected light beams, divided from the microscopic image by means of the beam splitter **212**, are landed on the operator- and mate-side optical systems La and Lb, respectively.

Further, the operator-side optical system La includes a main image display optical system La**1** for displaying a main microscopic image and an in-field display optical system La**2** for projecting an index and a sub-image, which is different from the main image, on a part of the microscopic field. The main image display optical system La**1** is provided with an objective lens **213***a*, LCD **214***a* for microscopic image masking, total-reflection mirror **215***a*, imaging lens **216***a*, prism **217***a*, and eyepiece **218***a*. The LCD **214***a* is located on a first imaging point **213***a***1** of the objective lens **213***a*.

The in-field display optical system La**2** is provided with an LCD (in-field monitor) **219***a* for in-field display, imaging lens **220***a*, prism **217***a*, and eyepiece **218***a*. The prism **217***a* and the eyepiece **218***a* are used in common in the main image display optical system La**1** and the in-field display optical system La**2**. The microscopic image from the main image display optical system La**1** and an in-field display image from the in-field display optical system La**2** are superposed and landed on the side of the eyepiece **218***a* by means of the prism **217***a*.

Likewise, the mate-side optical system Lb includes a main image display optical system Lb**1** for displaying a main microscopic image and an in-field display optical system Lb**2** for projecting an index and a sub-image, which is different from the main image, on a part of the microscopic field. The main image display optical system Lb**1** is provided with an objective lens **213***b*, LCD **214***b* for microscopic image masking, total-reflection mirror **215***b*, imaging lens **216***b*, prism **217***b*, and eyepiece **218***b*. The LCD **214***b* is located on a first imaging point **213***b***1** of the objective lens **213***b*.

The in-field display optical system Lb**2** is provided with an LCD (in-field monitor) **219***b* for in-field display, imaging lens **220***b*, prism **217***b*, and eyepiece **218***b*. The prism **217***b* and the eyepiece **218***b* are used in common in the main image display optical system Lb**1** and the in-field display optical system Lb**2**. The microscopic image from the main image display optical system Lb**1** and an in-field display image from the in-field display optical system Lb**2** are superposed and landed on the side of the eyepiece **218***b* by means of the prism **217***b*.

In the operating microscope **201** according to the present embodiment, an endoscopic image from an endoscope **221** shown in FIG. **30** is displayed on the respective LCD's **219***a* and **219***b* for in-field display of the operator- and mate-side optical systems La and Lb. A TV camera head **222** is coupled to the endoscope **221**. A CCTV unit **223** is connected to the camera head **222**. The endoscopic image of the endoscope **221** is picked up by means of the camera head **222**, and the resulting optical video image is photoelectrically converted by means of an image-pickup device (not shown) in the camera head **222**. Thereafter, the image is applied as an electrical signal to the CCTV unit **223** and processed, whereupon a TV signal is outputted.

As shown in FIG. **30**, moreover, an electric circuit block of the operating microscope **201** according to the present embodiment is provided with an operator-side processing system Ka and a mate-side processing system Kb. The CCTV unit **223** is connected with an in-field image generator circuit **224***a* of the operator-side processing system Ka and an in-field image generator circuit **224***b* of the mate-side processing system Kb.

The operator-side processing system Ka is provided with a first LCD driver **225***a* for driving the LCD **214***a* for microscopic image masking, a second LCD driver **226***a* for driving the LCD **219***a* for in-field display, a display changing circuit **227***a*, the in-field image generator circuit **224***a*, and a microscopic image masking processor **228***a*. Further, the in-field image generator circuit **224***a* and the microscopic image masking processor **228***a* are connected with an in-field display controller (input means) **229** for inputting observation conditions in which the size, position, etc. of images to be displayed on the LCD's **219***a* and **219***b* for in-field display are changed.

Furthermore, the in-field image generator circuit **224***a* and the microscopic image masking processor **228***a* are connected to the input side of the display changing circuit **227***a*. The first and second LCD drivers **225***a* and **226***a* are connected to the output side of the circuit **227***a*.

The output of the CCTV unit **223** is applied to the in-field image generator circuit **224***a* of the operator-side processing system Ka, the output of which is applied to the display changing circuit **227***a*. An output signal from the microscopic image masking processor **228***a* is also applied to the circuit **227***a*, the output of which is applied to the LCD drivers **225***a* and **226***a*. Further, output signals from the LCD drivers **225***a* and **226***a* are applied to the LCD **214***a* for microscopic image masking and the LCD **219***a* for in-field display, respectively.

The mate-side processing system Kb is provided with a third LCD driver **225***b* for driving the LCD **214***b* for microscopic image masking, a fourth LCD driver **226***b* for driving the LCD **219***b* for in-field display, a display changing circuit **227***b*, the in-field image generator circuit **224***b*, and a microscopic image masking processor **228***a*. Further, the in-field image generator circuit **224***b* and the microscopic image masking processor **228***b* are connected with the in-field display controller **229**.

In the mate-side processing system Kb according to the present embodiment, moreover, a first rotation computing

circuit (observational state changing means) **230** is interposed between the in-field image generator circuit **224***b* and the display changing circuit **227***b*, while a second rotation computing circuit (observational state changing means) **231** is interposed between the microscopic image masking processor **228***b* and the display changing circuit **227***b*.

The first and second rotation computing circuits **230** and **231** are connected to the input side of the display changing circuit **227***b*. Further, the third and fourth LCD drivers **225***b* and **226***b* are connected to the output side of the circuit **227***b*.

On the side of the mate-side processing system Kb, the output of the CCTV unit **223** is applied to the in-field image generator circuit **224***b* of the mate-side processing system Kb, the output of which is applied to the display changing circuit **227***b* via the first rotation computing circuit **230**. A signal from the microscopic image masking processor **228***b* is also applied to the display changing circuit **227***b* via the second rotation computing circuit **231**. The output of the circuit **227***b* is applied to the LCD drivers **225***b* and **226***b*. Further, output signals from the drivers **225***b* and **226***b* are applied to the LCD **214***b* for microscopic image masking and the LCD **219***b* for in-field display, respectively.

The position detecting encoder **211** is connected to the first and second rotation computing circuits **230** and **231**. An output signal from the encoder **211** is applied to the circuits **230** and **231**, while the control output of the in-field display controller **229** is applied to the in-field image generator circuits **224***a* and **224***b* and the microscopic image masking processors **228***a* and **228***b*.

The following is a description of the function of the operating microscope **201**. In starting the operation of the operating microscope **201** of the present embodiment, a microscopic image of an affected region in an operative field j (see FIG. **74**) as an object of surgical operation is divided into two parts for the operator- and mate-side optical systems La and Lb by means of the beam splitter **212**. The divided image for the operator-side optical system La is focused on the first imaging point **213***a***1** of the objective lens **213***a*, whereupon a microscopic image **232***a* for the optical system La is formed, as shown in FIG. **31**A. Further, the image for the mate-side optical system Lb, divided by means of the beam splitter **212**, is focused on the first imaging point **213***b***1** of the objective lens **213***b*, whereupon a microscopic image **232***b* for the optical system Lb is formed, as shown in FIG. **31**A.

In FIG. **30**, the endoscopic image shot by means of the endoscope **221** is picked up by means of the camera head **222**. The resulting optical video image is photoelectrically converted by means of the image-pickup device (not shown) in the camera head **222**. Thereafter, the image is applied as an electrical signal to the CCTV unit **223** and processed, whereupon a TV signal is outputted. The TV signal delivered from the CCTV unit **223** is applied to the respective in-field image generator circuits **224***a* and **224***b* of the operator- and mate-side processing system Ka and Kb.

The output signal processed in the in-field image generator circuit **224***a* of the operator-side processing system Ka is applied to the display changing circuit **227***a*. As this is done, the output signal from the microscopic image masking processor **228***a* is also applied to the circuit **227***a*. Further, the output signal from the circuit **227***a* is applied to the LCD drivers **225***a* and **226***a*. The control signals from the LCD drivers **225***a* and **226***a* are applied to the LCD **214***a* for microscopic image masking and the LCD **219***a* for in-field display, respectively.

Since the LCD **214***a* for microscopic image masking is located on the first imaging point **213***a***1** of the objective lens **213***a*, a mask portion **233***a* for sub-image is inserted into a part of the microscopic image **232***a* for the operator-side optical system La by means of the LCD **214***a*, as shown in FIG. **31**A. As this is done, moreover, an endoscopic image **234***a* is partially displayed on a part of the whole LCD screen of the LCD **219***a* for in-field display, and the remaining part is left as a shielding portion **235***a*, as shown in FIG. **31**B.

The image of FIG. **31**A that combines the microscopic image **232***a* and the mask portion **233***a* for sub-image inserted therein and the image of FIG. **31**B that combines the endoscopic image **234***a* and the shielding portion **235***a* are superposed by means of the prism **217***a*. Thereupon, a composite image **238***a* is formed having an endoscopic image (sub-image) **237***a* inserted in a microscopic image (main image) **236***a*, as shown in FIG. **32**A.

The same operation on the operator side is also carried out on the mate side. More specifically, the output signal processed in the in-field image generator circuit **224***b* of the mate-side processing system Kb is applied to the display changing circuit **227***b* through the first rotation computing circuit **230**. As this is done, the output signal from the microscopic image masking processor **228***b* is also applied to the circuit **227***b* through the second rotation computing circuit **231**.

Further, the output signal from the circuit **227***b* is applied to the LCD drivers **225***b* and **226***b*. The output signals from the LCD drivers **225***b* and **226***b* are applied to the LCD **214***a* for microscopic image masking and the LCD **219***a* for in-field display, respectively.

Since the LCD **214***b* for microscopic image masking is located on the first imaging point **213***b***1** of the objective lens **213***b*, a mask portion **233***b* for sub-image is inserted into a part of the microscopic image **232***b* for the mate-side optical system Lb by means of the LCD **214***b*, as shown in FIG. **31**A. As this is done, moreover, an endoscopic image **234***b* is partially displayed on a part of the whole LCD screen of the LCD **219***b* for in-field display, and the remaining part is left as a shielding portion **235***b*, as shown in FIG. **31**B.

The image of FIG. **31**A that combines the microscopic image **232***b* and the mask portion **233***b* for sub-image inserted therein and the image of FIG. **31**B that combines the endoscopic image **234***b* and the shielding portion **235***b* are superposed by means of the prism **217***b*. Thereupon, a composite image **238***b* is formed having an endoscopic image (sub-image) **237***b* inserted in a microscopic image (main image) **236***b*, as shown in FIG. **32**A.

As the in-field display controller **229** is operated, the observation conditions in which the size, position, etc. of the images to be displayed on the LCD's **219***a* and **219***b* for in-field display are changed are inputted. Depending on the conditions inputted by means of the controller **229**, the in-field image generator circuits **224***a* and **224***b* output control signals for changing the size, position, etc. of the images to be displayed on the LCD's **219***a* and **219***b*.

In the microscopic image masking processors **228***a* and **228***b*, moreover, the mask portions **233***a* and **233***b* are formed having the same size and position as the endoscopic images **234***a* and **234***b* that are generated by means of the in-field image generator circuits **224***a* and **224***b*, as shown in FIG. **31**A. Thus, the mask portion **233***a* of FIG. **31**A and the endoscopic image **234***a* of FIG. **31**B are equal in size.

According to the present embodiment, furthermore, two images are alternatively changed by means of the display changing circuit **227***a* by the operator's processing, and images are displayed individually on the LCD's **214***a* and

219*a* by means of the LCD drivers 225*a* and 226*a*. In the mate-side processing system, the images of FIGS. 31A and 31B, generated by means of the in-field image generator circuit 224*b* and the microscopic image masking processor 228*b*, are subjected to map conversion in the rotation computing circuits 230 and 231 in accordance with the output of the position detecting encoder 211 that detects the rotational angle of the mate eyepiece unit 209, and then rotated in the manner shown in FIGS. 31C and 31D. The images shown in FIGS. 31C and 31D are obtained by rotating the images of FIGS. 31A and 31B, respectively, for 1800 .

The mate-side image processed in this manner forms the composite image 238*b* of FIG. 32B, which is an image obtained by rotating the composite image 238*a* of FIG. 32A without changing the relative positions of the microscopic images 236*a* and 2326*b* and the endoscopic images 237*a* and 237*b* therein.

The following is a description of operation for the case where preoperative diagnostic images, such as X-ray CT's, are displayed on the LCD's 219*a* and 219*b* for in-field display of the operator- and mate-side optical systems La and Lb. According to the present embodiment, computer images, such as X-ray CT's (not shown), are applied to the in-field image generator circuits 224*a* and 224*b* of FIG. 30. In this case, the output of the circuit 224*b* is applied directly to the display changing circuit 227*b* without actuating the rotation computing circuits 230 and 231 of the mate-side processing system Kb. In consequence, composite images 240*a* and 240*b* are obtained including computer images 239*a* and 239*b* inserted in the microscopic images 236*a* and 2326*b*, as shown in FIGS. 33A and 33B, respectively. FIGS. 33A and 33B show the operator- and mate-use composite images 240*a* and 240*b*, respectively. The computer images 239*a* and 239*b*, which serve as in-field images in the microscopic images 236*a* and 236*b*, are common to the operator- and mate-use composite images 240*a* and 240*b*, and are displayed in like manner in a fixed direction.

FIGS. 35A and 35B show states in which indexes (markers) 242*a* and 242*b* are overlaid on microscopic images 241*a* and 241*b*, respectively. The microscopic images 241*a* and 241*b* are used on the operator side and on the mate side, respectively.

Further, FIG. 34A shows a mask image 243*a* or 243*b* overlain by the index 242*a* or 242*b*, and FIG. 34B shows an in-field display image. In this case, the mask size for the mask image 243*a* or 243*b* is reduced to zero, so that the index 242*a* or 242*b* appears as the in-field display image. The microscopic images 241*a* and 241*b* obtained in this case have their corresponding indexes 242*a* and 242*b* superposed thereon, as shown in FIGS. 35A and 35B, respectively.

If the mask portion 233*a* or 233*b* is larger than the endoscopic image 234*a* or 234*b* in FIGS. 31A to 31D, the endoscopic image 234*a* or 234*b* in the field has a frame (not shown). If the mask portion 233*a* or 233*b* is smaller than the endoscopic image 234*a* or 234*b*, on the other hand, the periphery of the endoscopic image 234*a* or 234*b* in the field is blurred.

In the case where the endoscopic image 234*a* or 234*b* in the field of the microscopic image 232*a* or 232*b* represents a graphic form, such as a line or circle, the graphic form is replaced with the microscopic image 232*a* or 232*b* if the mask portion 233*a* or 233*b* has the same shape as the in-field endoscopic image 234*a* or 234*b*. Overlay display is made if the mask portion 233*a* or 233*b* need not be formed.

The arrangement described above produces the following effects. In the mate-side processing system Kb according to the present embodiment, the first rotation computing circuit 230 is interposed between the in-field image generator circuit 224*b* and the display changing circuit 227*b*, while the second rotation computing circuit 231 is interposed between the microscopic image masking processor 228*b* and the display changing circuit 227*b*. Further, the position detecting encoder 211 for detecting the rotational angle of the mate eyepiece unit 209 with respect to the operator eyepiece unit 208 is connected to the first and second rotation computing circuits 230 and 231. If the mate eyepiece unit 209 is rotated with respect to the operator eyepiece unit 208 with the in-field image of an auxiliary optical system projected into the microscopic field so that the composite image 238*a* or 238*b* is formed including the endoscopic image 237*a* or 237*b* inserted in the microscopic 236*a* or 236*b*, as shown in FIG. 32A, therefore, the images of FIGS. 31A and 31B that are generated by means of the in-field image generator circuit 224*b* and the microscopic image masking processor 228*b* of the mate-side processing system Kb are subjected to map conversion in the rotation computing circuits 230 and 231 in accordance with the output of the position detecting encoder 211 that detects the rotational angle of the mate eyepiece unit 209, and then rotated in the manner shown in FIGS. 31C and 31D. Accordingly, the composite image 238*b* of FIG. 32B is displayed on the mate eyepiece unit 209 with the composite image 238*a* of FIG. 32A displayed on the operator eyepiece unit 208. If the mate eyepiece unit 209 is rotated with respect to the operator eyepiece unit 208, therefore, a microscopic field of the same positional relations for the operator can be continuously secured for the mate. Thus, the in-field image of the auxiliary optical system produces no dead angles in the microscopic field.

If necessary, moreover, an image in the same direction as the one on the operator side can be projected on the in-field image of the auxiliary optical system on the mate side by a simple method, or the in-field image can be displayed with a desired size and in a free position. Further, an index such as a marker overlaid on the microscopic image, as well as the in-field image of the auxiliary optical system, can be realized by only the image processing without changing the system configuration, so that a lot of types of display and observation methods can be selected without entailing any troublesome manipulation during the surgical operation. In consequence, necessary in-field information can be properly offered to the operator or his or her mate, and the aimed microscopic field can be easily secured during the operation.

Eighth Embodiment

FIGS. 36 and 37 show an eighth embodiment of the present invention. In the present embodiment, the configuration of the mate eyepiece unit 209 of the seventh embodiment is modified in the following manner.

According to the present embodiment, the rotation computing circuits 230 and 231 in the mate-side processing system Kb of the seventh embodiment are omitted or replaced with an LCD rotating mechanism 251 for rotating the LCD 214*b* for microscopic image masking and the LCD 219*b* for in-field display in the mate-side optical system Lb.

As shown in FIG. 37, the LCD rotating mechanism 251 of the present embodiment comprises a ring-shaped first LCD driving gear 252, to which the LCD 214*b* for microscopic image masking is fixed, and a ring-shaped second LCD driving gear 253, to which the LCD 219*b* for in-field display is fixed. The LCD 214*b* for microscopic image masking is fixed in the ring of the first LCD driving gear 252. Likewise, the LCD 219*b* for in-field display is fixed in the ring of the second LCD driving gear 253.

A gear **255** is fixed to the rotating shaft of a drive motor **254** of the LCD rotating mechanism **251**. The gear **255** is in mesh with an intermediate gear **256** as well as with the second LCD driving gear **253**. Further, the intermediate gear **256** is in mesh with the first LCD driving gear **252**. The gear ratio between the gears **255** and **256** is adjusted to **1**:**1**. Thus, the first and second LCD driving gears **252** and **253** can rotate in the same direction and at the same speed as the gear **255** rotates.

A motor control circuit **257** is connected to the drive motor **254**. A position detecting encoder **211** is connected to the circuit **257**. An output signal from the encoder **211** is applied to the circuit **257**, whereby the operation of the motor **254** is controlled.

The following is a description of the operation of the present embodiment arranged in this manner. If a mate eyepiece unit **209** is rotated with respect to an operator eyepiece unit **208**, according to the present embodiment, the output signal from the position detecting encoder **211**, corresponding to the rotational angle of the mate eyepiece unit **209**, is applied to the motor control circuit **257**. Thus, the circuit **257** controls the operation of the drive motor **254**.

As this is done, the motor **254** causes the gear **255** to rotate according to the rotational angle of the mate eyepiece unit **209**. The second LCD driving gear **253** is rotated in association with the rotation of the gear **255**, and the first LCD driving gear **252** is rotated through the medium of the intermediate gear **256**. Since the gear ratio between the gears **255** and **256** is adjusted to 1:1, the first and second LCD driving gears **252** and **253** rotate in the same direction and at the same speed. Accordingly, the positional relation between the LCD **219***b* for in-field display and the LCD **214***b* for microscopic image masking can be kept fixed, and image display equivalent to the one obtained by the image rotation shown in FIGS. **31**C and **31**D can be realized.

According to the present embodiment, therefore, the output signal from the position detecting encoder **211** that detects the rotational angle of the mate eyepiece unit **209** is applied to the motor control circuit **257**, and the operation of the drive motor **254** is controlled by means of the circuit **257**. Thus, if the mate eyepiece unit **209** is rotated with respect to the operator eyepiece unit **208**, according to the present embodiment, the LCD rotating mechanism **251** is driven according to the rotational angle o the mate eyepiece unit **209** by means of the motor **254**, so that the LCD **214***b* for microscopic image masking and the LCD **219***b* for in-field display in the mate-side optical system Lb can be rotated individually. According to the present embodiment, therefore, a lot of types of display and observation methods can be selected without entailing any troublesome manipulation during the surgical operation, as in the case of the first embodiment, and besides, the in-field image can be offered without lowering the image quality during image computation for the image rotating process.

Ninth Embodiment

FIG. **38**A shows a ninth embodiment of the present invention. In the present embodiment, the LCD rotating mechanism **251** of the eighth embodiment is modified in the following manner.

The LCD rotating mechanism **251** of the eighth embodiment is designed so that the LCD **214***b* for microscopic image masking and the LCD **219***b* for in-field display in the mate-side optical system Lb are rotated individually by means of the gear mechanism. However, the present embodiment is provided with an LCD rotating mechanism **261** that is formed of a belt drive mechanism.

The LCD rotating mechanism **261** of the present embodiment comprises a first LCD driving pulley **262**, to which the LCD **214***b* for microscopic image masking is fixed, and a second LCD driving pulley **263**, to which the LCD **219***b* for in-field display is fixed.

A pulley **264** is fixed to the rotating shaft of a drive motor (not shown) of the LCD rotating mechanism **261**. Further, an endless belt **265** is passed around and between the pulley **264** and the first and second LCD driving pulleys **262** and **263**. The driving pulleys **262** and **263** are equal in diameter. Thus, the first and second LCD driving pulleys **262** and **263** can rotate in the same direction and at the same speed.

As in the case of the eighth embodiment, moreover, the motor control circuit **257** (see FIG. **36**) is connected to the drive motor for the pulley **264**. The position detecting encoder **211** is connected to the circuit **257**. An output signal from the encoder **211** is applied to the circuit **257**, whereby the operation of the drive motor is controlled.

The following is a description of the operation of the present embodiment arranged in this manner. If a mate eyepiece unit **209** is rotated with respect to an operator eyepiece unit **208**, according to the present embodiment, the output signal from the position detecting encoder **211**, corresponding to the rotational angle of the mate eyepiece unit **209**, is applied to the motor control circuit **257**. Thus, the circuit **257** controls the operation of the drive motor.

As this is done, the motor causes the pulley **264** to rotate according to the rotational angle of the mate eyepiece unit **209**, and the first and second LCD driving pulleys **262** and **263** are rotated in the same direction and at the same speed by means of the belt **265**. Accordingly, the positional relation between the LCD **219***b* for in-field display and the LCD **214***b* for microscopic image masking can be kept fixed, and image display equivalent to the one obtained by the image rotation shown in FIGS. **31**C and **31**D can be realized. Thus, the present embodiment can provide the same effects of the second embodiment.

Tenth Embodiment

FIG. **38**B shows a tenth embodiment of the present invention. In the present embodiment, the respective configurations of the operator- and mate-side LCD's **214***a* and **214***b* for microscopic image masking of the seventh embodiment are modified in the following manner.

As shown in FIG. **38**B, the present embodiment is provided with a support frame **272** that has a circular window **271**. The window **271** of the frame **272** is located on the first imaging point **213***a***1** of the objective lens **213***a*.

A shielding plate **273** is movably supported on the support frame **272** so as to cover a part of the circular window **271**. Further, racks **274** are formed individually on the opposite sides of the shielding plate **273**. The racks **275** are in mesh with driving gears **275**, individually. The gears **275** are fixed to the rotating shaft of a motor **276**. As the gears **275** rotate, the shielding plate **273** is advanced or retreated so as to cover a part of the window **271** of the frame **272**.

The following is a description of the operation of the present embodiment arranged in this manner. According to the present embodiment, the drive of the motor **276** is controlled by means of a control signal delivered from in-field display range setting means (not shown). As the motor **276** rotates, the gear **275** rotates. In association with the rotation of the gear **275**, the shielding plate **273** moves in the direction of the arrow in FIG. **38**B, whereupon the area of the part of the circular window **271** that is covered by the support frame **272** is changed. Thus, the microscopic image masking area is changed.

The arrangement described above also fulfills the same functions of the operator- and mate-side LCD's **214***a* and **214***b* for microscopic image masking of the seventh embodiment. Thus, the present embodiment can provide the same effects of the seventh embodiment.

Eleventh Embodiment

FIGS. **39** to **42**B show an eleventh embodiment of the present invention. FIG. **39** shows an outline of the whole system of an operating microscope apparatus **281** according to the present embodiment.

The operating microscope apparatus **281** of the present embodiment comprises an operating microscope **282** constructed substantially in the same manner as the operating microscope **201** of the seventh embodiment, index/in-field display controller **283**, position information computing means **284**, and position detecting means **285** for detecting the position of the operating microscope **282**.

A stand **286** of the operating microscope **282** of the present embodiment is provided with a base **287** movable on a floor surface and a support post **288** set up on the base **287**.

Further, the support post **288** is provided, on its top portion, with a body **289** of the operating microscope **282**, including an optical system for observing an affected region, and a support mechanism **290** for supporting the body **289** for movement in any desired direction. The mechanism **290** is a combination of a plurality of moving arms **291** for locating the microscope body **289** in a desired position.

Furthermore, the microscope **282** is connected with the index/in-field display controller **283**, position information computing means **284**, and position detecting means **285**. The microscope **282** is supplied with an index/in-field display control signal **292** from the controller **283** and a position information computing means image signal **293** and an arm driving signal **294** from the computing means **284**.

FIG. **40**B is an exterior view of the index/in-field display controller **283**. A body **295** of the controller **283** is provided with a joystick **296** and two switches **297** and **298**. An index control signal **283***a* is delivered from the controller **283** to the position information computing means **284**.

FIG. **40**A shows a microscopic image **299** of the operating microscope **282**. A position information computing means image **300** and a marker **301** are displayed in the field of the microscopic image **299**. Two indexes **302***a* and **302***b* are displayed in the image **300**.

The following is a description of the operation of the present embodiment. According to the present embodiment, the microscope **282** is supplied with the position information computing means image signal **293** from the position information computing means **284**. The image signal **293** is displayed as an in-field display image **304** on an LCD **303** for in-field display, as shown in FIG. **41**B. A preoperative image, such as an X-ray CT, is displayed in the in-field display image **304**. Further, the indexes **302***a* and **302***b* are displayed in the image **304**, while the marker **301** is displayed on the LCD **303**.

A microscopic image mask **306**, which is as large as the in-field display image **304**, is displayed on an LCD **305** for microscopic image masking shown in FIG. **41**A. A microscopic image **308** shown in FIG. **42**B is superposed on a microscopic image **307** shown in FIG. **42**A.

Referring to FIG. **40**A, the index **302***a* in the position information computing means image **300**, an MIR or X-ray CT diagnostic image, and the marker **301** in the field of the microscopic image **299** are pointed in the same direction in the operative field.

The joystick **296** and switches **297** and **298** of the controller **283** of FIG. **40**B are operated to transmit the index control signal **283***a* to the position information computing means **284**. Based on this information, the control means **284** transmits the image, moved to the indexes **302***a* and **302***b*, as shown in FIG. **40**A, to the microscope **282** in response to the position information computing means image signal **293**, and displays the image in the in-field display image **304** of the microscope **282**.

Further, the position information computing means **284** controls the support mechanism **290** of the microscope **282** in response to the arm driving signal **294**, thereby moving the microscope body **289** so that the index **302***b* and the marker **301** are situated in the same position in the operative field.

According to the present embodiment arranged in this manner, the operator can designate his or her desired view point on a position information computing means image, and the observational position can be automatically moved to the point. Thus, the field of vision can be easily moved to a target region during the surgical operation.

Twelfth Embodiment

FIGS. **43** to **47** show a twelfth embodiment of the present invention.

FIG. **43** shows an outline of an operating microscope apparatus **401** and an endoscopic apparatus according to the present embodiment. The microscopic apparatus **401** of the present embodiment is supported on a stand **402**. The stand **402** is provided with a base **402***a* movable on a floor surface and a support post **402***b* set up on the base **402***a*. A moving arm mechanism **404** for movably supporting a microscope body **403** of the microscopic apparatus **401** is provided on the top portion of the support post **402***b*. The mechanism **404** is formed of a plurality of moving arms including first, second, and third arms **405**, **406** and **407** and a swing arm **408**.

One end of the first arm **405** is mounted on the upper end portion of the support post **402***b* for rocking motion around an axis Oa. The first arm **405** has an illumination light source (not shown) therein. One end of the second arm **406** is mounted on the other end of the first arm **405** for rocking motion around an axis Ob.

The second arm **406** is a pantograph arm that is formed of a link mechanism and a balancing spring member, whereby the microscope body **403** can be moved in the vertical direction. The third arm **407** is mounted on the other end of the second arm **406** for rocking motion around an axis Oc.

The proximal end portion of the swing arm **408** is coupled to the third arm **407**. The microscope body **403**, a binocular tube **409** for stereoscopic observation, and a handle **410** are provided on the distal end portion of the arm **408**. The swing arm **408** is supported for longitudinal swinging motion such that it causes the microscope body **403** to rock in the longitudinal direction around an axis Od, which extends at right angles to the drawing plane of FIG. **43**, with respect to the direction of the operator's observation, and for transverse swinging motion such that it causes the microscope body **403** to rock in the transverse direction of the operator around an Oe.

Further, electromagnetic brakes (not shown) are provided individually on rocking portions corresponding to the axes Oa to Oe of the moving arm mechanism **404**, whereby the position of the microscope body **403** can be freely spatially adjusted and fixed. These brakes are designed so that their locking or free state can be freely selected by operating a

switch (not shown) on the handle **410**. Preferably, a light source unit (not shown) for the moving arm mechanism **404** should be incorporated in the support post **402***b* of the stand **402**, for example.

The binocular tube **409** of the microscope body **403** is formed having left- and right-hand observational optical paths for stereoscopic observation. Each of the observational optical paths of the lens tube **409** is provided with an objective lens (not shown) and a variable-scale optical system (not shown). Numeral **440** denotes an endoscopic system for observing dead angles of the operating microscope.

As shown in FIG. **44**, the endoscopic system **440** comp a rigid scope **441** having an observation port axis Og at a given angle to the direction of insertion, a TV camera **442** including a TV camera head **442***a* for picking up an observational image of the scope **441** and a TV controller **442***b*, and a monitor **443** connected to the controller **442***b* and displaying the observational image of the scope **441**. The rigid scope **441** is fixed to a bedside stay **445** by means of a scope holder **444**.

The scope holder **444** is provided with a fixing portion **446** fixed to the bedside stay **445**, vertical arm **447**, moving arms **448***a* and **448***b*, slanting arm **449**, and holding portion **450**, which are connected to one another in the order named. The arms **447**, **448***a*, **448***b* and **449** and the holding portion **450** are rotatable around axes Op, Oq, Or, Os and To, respectively. Electromagnetic brakes **451***a* to **451***e* are provided individually at portions corresponding to these axes of rotation, whereby the position of the rigid scope **441** can be freely three-dimensionally adjusted and fixed.

These electromagnetic brakes are designed so that their locking or free state can be selected by operating a switch **452** on the holding portion **450**. The switch **450** and the brakes **451***a* to **451***e* are connected to a holder control section **453**. The control section **453** is provided with a driver circuit (not shown), which outputs driving signals for disengagement to the brakes **451***a* to **451***e* while an operating signal from the switch **452** is being inputted, and a circuit that delivers the input signal from the switch **452** to an in-field display controller **454** (mentioned later).

FIG. **45** shows an outline of the binocular tube **409** according to the present embodiment. The lens tube **409** is provided with a right-eye observational optical system **411** shown in FIG. **45** and a left-eye observational optical system (not shown). FIG. **45** shows a part of the right-eye optical system **411**, viewed from the lateral of the lens tube **409**. Since the left-eye observational optical system is constructed in the same manner as the optical system **411** shown in FIG. **45**, the following is a description of the optical system **411** only.

The right-eye optical system **411** according to the present embodiment comprises a binocular tube optical system (first observational optical system) **412** for observing the observational image of the operating microscope and an image projection optical system (second observational optical system) **413** for observing optional image information that is different from the observational image. The binocular tube optical system **412** is provided with an imaging optical system **414**, image rotator **415**, parallelogrammatic prism **416**, and eyepiece optical system **417**. The observational image of the operating microscope, incident upon the binocular tube optical system **412**, is guided from the imaging optical system **414** to the eyepiece optical system **417** via the image rotator **415** and the prism **416** in succession.

Further, the image projection optical system **413** is provided with an LCD display **420** as an in-field display function, collimating optical system **421**, variable-scale optical system **422** having a variable projection magnification, imaging optical system **423**, and movable prism **424**. The prism **424**, which is oriented in the direction of arrow S within the plane of a reflective surface **424***a*, is movable with respect to the image projection optical system **413** by means of a motor **425***a*. On the other hand, the variable-scale optical system **422** is connected so that its magnification can be changed by driving a motor **425***b*.

The movable prism **424** and the variable-scale optical system **422** are driven in a relation such that the image on the LCD display **420** is enlarged in proportion to the depth of insertion of the prism **424** in the binocular tube optical system **412** as it is projected by means of the optical system **422**.

The image information displayed on the LCD display **420** is guided to the eyepiece optical system **417** successively through the collimating optical system **421**, variable-scale optical system **422**, imaging optical system **423**, and movable prism **424**. The eyepiece optical system **417** ensures simultaneous observation of the observational image of the operating microscope transmitted through the binocular tube optical system **412** and the optional image information transmitted through the image projection optical system **413**.

Numeral **454** denotes the in-field display controller (display format changing means), which is connected to the holder control section **453** to which the switch **452** of the scope holder **444** is connected, LCD display **420**, TV controller **442***b*, and motors **425***a* and **425***b*. The controller **454** is composed of driver circuits for the motor **425***a* for moving the prism **424** and the motor **425***b* for driving the variable-scale optical system **422**, control circuits for controlling the drive of the driver circuits, and a display control circuit that is supplied with a video signal from the TV controller **442***b* of the TV camera **442** and displays an image on the LCD display **420**.

The observational image of the operating microscope apparatus **401** ensures stereoscopic observation of an affected region through the microscope body **403** by means of the binocular tube optical system **412** of the binocular tube **409**. As this is done, the movable prism **424** of the image projection optical system **413** is on the optical path of the binocular tube optical system **412**, as shown in FIG. **45**. The image of the affected region observed through the rigid scope **441** is picked up by means of the TV camera head **442***a* shown in FIG. **44**. This image is displayed on the monitor **443** and the LCD display **420** by means of the TV controller **442***b* and the in-field display controller **454** shown in FIG. **45**, respectively. The display image is observed through the image projection optical system **413** and the eyepiece optical system **417**.

FIG. **46** shows a state of observation for the case where the image of the rigid scope is mainly observed as the surgical operation is carried out. In FIG. **46**, numerals **455** and **456** denote a microscopic image and an image observed through the rigid scope **441**, respectively. The rigid scope **441** itself is displayed in the microscopic image **455**.

On the other hand, the operator can change the observational position of the rigid scope **441** by depressing the switch **452** of the scope holder **444** to disengage the electromagnetic brakes **451***a* to **451***f*. By doing this, the rigid scope **441** can be freely moved in a three-dimensional manner. As this is done, the holder control section **453** disengages the electromagnetic brakes **451***a* to **451***b* to cancel the locked state, and delivers an ON-signal of the switch **452** to the in-field display controller **454**.

On receiving this input signal, the in-field display controller **454** drives the motors **425***a* and **425***b* to a previously stored specified extent, and the depth of insertion of the movable prism **424** in the binocular tube optical system is reduced. At the same time, the magnification of the variable-scale optical system **422** is changed into (or lowered to) a value that is settled properly for the movement of the movable prism **424**. Thereupon, the image observed through the eyepiece optical system **417** looks like the one shown in FIG. **47**. Thus, the image **456** of the rigid scope, compared to the microscopic image **455**, moves to an end of the field of vision, and is displayed in a contracted form.

In this manner, the image **456** of the rigid scope **441**, compared to the observational image **455** of the operating microscope, is observed in a wide range in the case where the observational position of the scope **441** is fixed, and in a narrow range if the observational position of the scope **441** is changed (or if the scope **441** is moved). When no normal rigid scope observation is carried out, a footswitch (not shown) of the microscope can be operated entirely to remove the movable prism **424** from the optical path of the binocular tube optical system **412** with ease. Thus, observation can be effected in the same manner as the observation by means of the conventional operating microscope.

The rigid scope image **456** is displayed wide on the observational image **455** of the operating microscope when it is used for a required treatment or observation, so that the treatment operation is easy. Since the display of the rigid scope image **456** is small while the rigid scope **441** is being moved, on the other hand, the state of insertion of the rigid scope **441** in the microscopic image **455** can be observed satisfactorily.

According to the present embodiment, the operating state of the rigid scope **441** is detected by detecting the disengagement of the scope holder **444** for holding the scope **441**, so that the surgical operation can be smoothly carried out without requiring use of any special device for detection and its operation.

Further, the movement of the rigid scope **441** can be detected more easily than by using an optical position detector according to a thirteenth embodiment described below.

Thirteenth Embodiment

FIGS. **48** to **50**B show a thirteenth embodiment.

As is schematically shown in FIG. **48**, an operating microscope apparatus **401** and an endoscopic system **440** according to the present embodiment are constructed in the same manner as the ones according to the twelfth embodiment, so that a detailed description of those elements is omitted. The following is a description of the optical position detector for the operating microscope apparatus **401** and the endoscopic system **440**. This optical position detector may be a conventional one.

As shown in FIG. **48**, emissive indexes **460** and **461** are attached to the operating microscope apparatus **401** and the endoscopic system **440**, respectively. The indexes **460** and **461** can be shot by means of an illuminant image-pickup device **462** that is provided with image-pickup means. The device **462** is connected with a position detecting section **463** for computing the position and angle of an illuminant in response to a signal from the device **462**. The position detecting section **463** is composed of a position data computing section for a microscope body **403**, a position data computing section for a rigid scope **441**, and a position calculating section for calculating the position of the rigid scope **441** relative to the position of the microscope body **403**. The detecting section **463** delivers information on the observational direction of the rigid scope with respect to the microscope body **403** to an in-field display controller **464**, which will be mentioned later.

FIG. **49** shows an outline of a binocular tube **465** according to the present embodiment.

A binocular tube optical system **412** of the binocular tube **465** is constructed in the same manner as the one according to the twelfth embodiment. Therefore, a description of the system **412** is omitted, and the following is a description of an arrangement of an image projection optical system **469**, a unique element.

The image projection optical system **469** comprises an LCD display **420** for use as an in-field display function, collimating optical system **466**, imaging optical system **467**, and prism **468**. Image information displayed on the LCD display **420** is guided to an eyepiece optical system **417** successively through the collimating optical system **466**, imaging optical system **467**, and prism **468**.

The image projection optical system **469**, which is incorporated in a chassis **470**, is connected so that it can be rocked integrally with the chassis **470** around an optical axis Of of the eyepiece optical system **417** of the binocular tube **465** by means of a motor **471**. The eyepiece optical system **417** ensures simultaneous observation of the observational image of the operating microscope transmitted through the binocular tube optical system **412** and optional image information transmitted through the image projection optical system **469**.

The in-field display controller **464** is connected to the position detecting section **463** of the aforesaid optical position detector, a TV controller **442***b*, the LCD display **420**, and the chassis rotating motor **471**. The controller **464** is composed of a driver circuit for the chassis rotating motor **471**, control circuit for controlling the drive of the driver circuit, display control circuit for the LCD display **420**, control circuit for controlling the rotation of the motor **471** in response to a position signal from the position detecting section **463**, and a display control circuit that is supplied with a video signal from the TV camera **442** and displays an image on the LCD display **420**.

The observational image of the operating microscope apparatus according to the thirteenth embodiment ensures stereoscopic observation of an affected region through the microscope body **403** by means of the binocular tube optical system **412** of the binocular tube **465**. As this is done, the movable prism **468** of the image projection optical system **469** is on the optical path of the binocular tube optical system **412**, as shown in FIG. **49**. The image of the affected region observed through the rigid scope **441** is picked up by means of a TV camera head **442***a*. This image is displayed on a monitor **443** and the LCD display **420** by means of the TV controller **442***b* and the in-field display controller **464**, respectively. The display image on the display **420** is observed through the image projection optical system **469** and the eyepiece optical system **417**.

During a surgical operation, the respective positions of the microscope body **403** and the rigid scope **441** are always detected by means of a conventional optical position detector. The position detecting section **463** obtains the direction (angle) of observation of the rigid scope **441** with respect to the observation direction of the microscope body **403**, and delivers angle information to the in-field display controller **464**. In response to this angle information, the controller **464** rotates the motor **471** as required, thereby causing the image

projection optical system **469** always to rotate integrally with the chassis in the same direction as the observation direction of the rigid scope. FIGS. **50**A and **50**B show states that are observed by means of the eyepiece optical system **417**. In this case, an image of the rigid scope **441** is displayed in the same direction as the observational direction (indicated by arrow B) of the scope **441**.

According to the operating microscope **401** of the present embodiment, the image **456** that is obtained through the rigid scope **441** and displayed in the field of observation is displayed in the same direction as the observational direction of the rigid scope, so that the operator can intuitively recognize the observational direction of the rigid scope **441**. Thus, the operator can be intent on the surgical operation without suffering troublesomeness, and therefore, the operation time can be shortened.

Since the optical position detecting means is used in the present embodiment, moreover, the system is readily compatible with a conventional navigation system that displays the respective observational positions of the surgical operation and the rigid scope **441** on a diagnostic image.

According to the present embodiment, furthermore, the optical position detecting means is used to detect the observational direction of the rigid scope **441** with respect to the microscope body **403**. Alternatively, however, the observational direction of the rigid scope **441** can be easily detected by means of an encoder or the like that is attached to a joint portion of the scope holder of the twelfth embodiment and serves as rotational angle detecting means. In this case, a simple system can be enjoyed.

Fourteenth Embodiment

A fourteenth embodiment will be described with reference to FIG. **51**. According to the present embodiment, the operating microscope apparatus of the twelfth embodiment is modified so that the binocular tube is designed differently and its visibility is automatically adjusted to the operator's eyes.

FIG. **51** shows an outline of a binocular tube **480** according to the present embodiment. The binocular tube **480** is provided with a binocular tube optical system (first observational optical system) **412**, which is similar to the one according to the first embodiment, an image projection optical system **481** for observing optional image information that is different from an observational image, a measurement optical system **487** for refractive index measurement, and a light receiving optical system **488**. The optical systems **481**, **487** and **488** constitute a second observational means. A detailed description of the binocular tube optical system **412**, which is constructed in the same manner as the one according to the twelfth embodiment, is omitted.

The image projection optical system **481** comprises an LCD display **482** for use as in-field display means, collimating optical system **483**, imaging optical system **484**, and movable prism **485**. A dichroic mirror **486** is located on an optical path between the prism **485** and the imaging optical system **484**. The movable prism **485** is provided on the optical path in a manner such that it can be removed by means of a motor (not shown).

The measurement optical system **487** comprises the movable prism **485**, the dichroic mirror **486**, a half-mirror **489**, a slit plate **490** in a position conjugate to the eyeground of a subject eye having a reference refractive force, a diffuser panel **491**, and a light emitting diode for emitting infrared light. Thus, the optical system **487** shares some components with the image projection optical system **481**.

The light receiving optical system **488** comprises the movable prism **485**, the dichroic mirror **486**, the half-mirror **489**, a shielding member **494** in a position conjugate to the slit plate **490**, and a light receiving element **495** in a position conjugate to the pupil. Thus, the optical system **488** shares some components with the measurement optical system **487**. Numeral **496** denotes a measurement section for computing the refractive force of the subject eye according to the light quantity distribution of the light receiving element **495**. The measurement section **496** is connected to a visibility correction motor drive control section **499** and an in-field display controller **500** (mentioned later), as well as to the light emitting diode **492**.

The eyepiece optical system **417** ensures simultaneous observation of the observational image of the operating microscope transmitted through the binocular tube optical system **412** and optional image information transmitted through the image projection optical system **481**. Further, the optical system **417** is designed so that it can make visibility adjustment by moving in the direction of its optical axis Of. A motor **498** can be used for the movement in the direction of the optical axis Of. Numeral **499** denotes the visibility correction motor drive control section that is connected to the motor **498** and the in-field display controller (mentioned later). The control section **499** is provided with a driver circuit for the motor **498** and a control circuit for controlling the drive of the motor. The motor **498** and the visibility correction motor drive control section **499** constitute visibility correction motor drive means.

The in-field display controller **500** is connected to the LCD display **482**, the measurement section **496**, a switch **502** that is connected to the operating microscope apparatus, a motor (not shown) for the movable prism **485**, and an external image apparatus. The controller **500** comprises a motor drive control circuit for the prism **485**, a display control circuit, and a driving signal output circuit for driving the measurement section. The display control circuit displays an image on the LCD display **482** and displays a stored fixed-view display pattern for measurement in response to input from the switch **502**.

The observational image of the operating microscope according to the present embodiment and the image displayed on the LCD display **482** are observed through the eyepiece optical system **417** in the same processes of operation of the twelfth and thirteenth embodiments. The images can be observed in the same manner as in the conventional operating microscope if the movable prism **485** is removed from the optical path.

The following is a description of visibility adjustment.

If the operator turns on the switch **502** of the operating microscope apparatus, the in-field display controller **500** displays the previously stored fixed-view display pattern on the LCD display **482**. This image is observed through the image projection optical system **481** and the eyepiece optical system **417** by the operator. The operator's eyes are fixed as they gaze steadily at the fixed-view display pattern. At the same time, the controller **500** causes the measurement section **496** to start measuring the refractive force.

The following is a description of operation for the refractive force measurement.

In response to a signal from the measurement section **496**, infrared light is emitted from the light emitting diode **492**. This infrared light is projected on the operator's eyeground via a slit (not shown) of the slit plate **490**, half-mirror **489**, dichroic mirror **486**, movable prism **485**, and eyepiece optical system **417**. Thus, a slit image of the slit plate **490** is projected on the eyeground.

The projected infrared light is reflected by the eyeground and delivered to the light receiving element **495** via the eyepiece optical system **417**, the movable prism **485**, the dichroic mirror **486**, the half-mirror **489**, a mirror **493**, and the shielding member **494**. Based on information on the light quantity distribution from the light receiving element, the measurement section computes the refractive force of the operator's eyes. Based on the result of this computation, the visibility correction motor drive control section causes the motor **498** to rotate, thereby moving the eyepiece optical system **417** for a required distance in the direction of the optical axis Of. Thereupon, the operator's visibility adjustment is completed.

The operating microscope of the present embodiment has a very simple construction, since the image projection optical system, which can display another image in the field, and the optical systems (measurement optical system and light receiving optical system) for measuring the refractive force share some of their components. Since the optical path separate from the one for the observational image of the operating microscope is used, moreover, the observational performance of the microscope cannot be ruined.

Since the fixed-view display that causes the operator to gaze steadily at the image is made on the LCD display screen, furthermore, accurate measurement can be accomplished without being influenced by the focusing capability of the eyes.

Further, the observational performance of the operating microscope cannot be lowered if the movable prism is removed from the optical path.

Fifteenth Embodiment

According to a fifteenth embodiment shown in FIGS. **52** to **53**B, an image of a nerve monitor device that displays the nerve state of a patient in the field of an operating microscope during a surgical operation. The present embodiment differs from the twelfth embodiment only in the construction of the in-field display controller.

As shown in FIG. **52**, an in-field display controller **510** of the present embodiment is connected to a binocular tube **409** that is similar to the one according to the twelfth embodiment. A nerve monitor device **511** displays a wavy image indicative of the nerve state on a monitor (not shown), and delivers a video signal for the wavy image to the controller **510**. Further, the monitor device **511** is provided with abnormal signal output means through which the operator can be informed of change of the nerve state. The output means is connected to the controller **510**.

The in-field display controller **510** is composed of driver circuits for a motor **425***a* for moving the movable prism **424** of the twelfth embodiment and a motor **425***b* for driving the variable-scale optical system **422**, control circuits that are supplied with signals from the abnormal signal output means from the nerve monitor device **511** and controls the drive of the motors **425***a* and **425***b*, and a display control circuit that is supplied with a video signal from the monitor device **511** and displays an image on an LCD display **420**.

In the operating microscope according to the present embodiment, an image **515** of the nerve monitor device **511** is normally displayed in the field of the operating microscope in the manner shown in FIG. **53**A during the surgical operation. If the nerve state of the patient is changed during the operation, a signal is outputted from the abnormal signal output means of the monitor device **511**, whereupon the in-field display controller **510** drives the motors **425***a* and **425***b* in the same manner as in the twelfth embodiment.

In consequence, the nerve monitor image **515** is displayed wide, as shown in FIG. **53**B.

Thus, the operator can easily recognize the nerve state of the patient.

According to the operating microscope of the present embodiment, therefore, the size of the display information of the nerve monitor device varies despite the operator's concentration on the surgical operation, so that the operator never overlooks the change of the patient's nerve state.

The following is a description of rigid scope systems according to three alternative embodiments that are applicable to the surgical system described above. These embodiments are solutions to the rigid scopes described in Jpn. UM Appln. KOKAI Publications Nos. 5-78201 and 56-176703, U.S. Pat. No. 5,168,863, and Jpn. Pat. Appln. KOKAI Publication No. 11-155798. More specifically, these alternative embodiments are intended to improve a rigid scope that is adapted to be inserted into the body cavity under surgical microscopic observation and ensure observation in the direction at a given angle to the direction of insertion, to prevent the rigid scope and a TV camera and a light guide connected thereto from hindering the microscopic observation or surgical operation, and to enable the operator to observe desired positions with ease.

Sixteenth Embodiment

A system according to a sixteenth embodiment will now be described with reference to FIGS. **54** and **55**.

FIG. **54** shows a general configuration of a rigid scope system. In FIG. **54**, numeral **601** denotes a body of an operating microscope. The microscope body **601** is held over an affected region by means of an arm stand (not shown) in a manner such that its observational direction can be changed freely. Numeral **602** denotes a rigid scope, which comprises an insert member **603** adapted to be inserted into the affected region (body cavity) and having an objective lens and an internal light guide (mentioned later) fixed therein, a coupling portion **604** composed of first and second bent portions **604***a* and **604***b*, and a grip portion **605** having an eyepiece. Symbol R designates a point of observation of the rigid scope **602**.

An upper surface **604***c* of the coupling portion **604** is coated with light absorbing paint such as matte black. The grip portion **605** has therein a camera connecting portion, which is connectable with a TV camera **606** that is connected optically to an imaging lens (mentioned later).

Numeral **607** denotes an external light guide, one end of which is connected to a light source unit (not shown). A connector **607***a* on the other end of the light guide **607** can be attached to and detached from a light guide mouthpiece **608** that projects substantially parallel to the bending direction of the first bent portion **604***a*, at the upper end of the insert portion **603** of the rigid scope **602**.

The construction of the rigid scope **602** will now be described in detail with reference to FIG. **55**. An objective lens **609** is provided in the distal end portion of the insert portion **603**. The lens **609** is fixed obliquely to the distal end of the insert portion **603** so that it is inclined at a given angle a to the longitudinal direction of the insert portion **603**. A prism **610** and a relay optical system **611** are also arranged in the insert portion **603**. The respective optical axes of the objective lens **609** and the optical system **611** are kept at the aforesaid angle a with the prism **610** between them.

A prism **612** is located in the first bent portion **604***a* of the coupling portion **604**, whereby an observational optical axis

O1 of the relay optical system **611** can be bent at about 90°. A relay optical system **613** is provided in an intermediate portion of the coupling portion **604**, and a prism **614** is disposed in the second bent portion **604***b* of the coupling portion **604**. The prism **614** serves to bend the observational optical axis, bent by means of the prism **612**, so as to extend substantially in the longitudinal direction of the insert portion **603**. Further, the grip portion **605** has therein a relay optical system **615** located on a luminous flux that is guided by means of the prism **614**. An imaging lens **616** is disposed in the rear end portion of the grip portion **605**. The lens **616** serves to focus an observational luminous flux on an image-pickup device **617** of the TV camera **606**.

A cable **618** that is connected electrically to the image-pickup device **617** of the TV camera **606** is connected to a drive unit (not shown), and a TV monitor (not shown) is connected electrically to the drive unit. The TV camera **606** is detachably connected to the grip portion **605** by means of a mounting screw portion **619**.

In the vicinity of the objective lens **609**, an illuminating lens **620** is disposed in the distal end of the insert portion **603**. The distal end of an internal light guide **621** is fixed to the inside of the lens **620** in a manner such that it is situated on the optical axis of the lens **620** and that the respective centers of the guide **621** and the lens **620** are substantially aligned with each other. The illuminating lens **620** and the internal light guide **621** constitute an illumination optical system according to the present embodiment. In a space portion **622** that is defined at the junction between the insert portion **603** and the coupling portion **604**, the light guide **621** is fixed to the light guide mouthpiece **608** with some slack. The light guide mouthpiece **608** is formed having a mounting screw portion **623** that serves to connect the external light guide **607** optically to the internal light guide **621**.

The coupling portion **604** is provided with a bearing portion **624**, which engages a flange **625** on the rear end of the insert portion **603** so as to hold the insert portion **603** for rotation around its longitudinal central axis. The bearing portion **624** and the flange **625** constitute a rotation mechanism portion **626**.

With the arrangement described above, the operator operates the arm stand (not shown) that supports the operating microscope body **601**, thereby adjusting the microscope body **601** to a desired position and angle. Further, illumination light is applied to the affected region through the microscope body **601**, and the affected region is subjected to enlarged-scale observation.

Then, the observational dead-angle region R of the operating microscope in the affected region is observed by means of the rigid scope **602**. First, the connector **607***a* of the external light guide **607** is connected to the light guide mouthpiece **608** of the rigid scope **602**, and the other end of the light guide **607** is connected to the light source unit (not shown). Further, the cable **618** of the TV camera **606** is connected to the drive unit (not shown).

As shown in FIG. **54**, the insert portion **603** is inserted into the affected region with the grip portion **605** and the TV camera **606** kept at a distance L from the microscope body **601**, and the objective lens **609** is directed to a position near the observational dead-angle region R.

The illumination light emitted from the light source (not shown) guided to the observational dead-angle region R by means of the external light guide **607**, internal light guide **621**, and illuminating lens **620**. The light from the region R is transmitted through the objective lens **609**, prism **610**, and relay optical system **611**, and then bent at about 90° by means of the prism **612**. After it is transmitted through the relay optical system **613**, moreover, the light is bent in the same direction as the longitudinal direction of the insert portion **603** by means of the prism **614**, and focused on the image-pickup device **617** of the TV camera **606** via the relay optical system **615** and the imaging lens **616**. A video image of the observational dead-angle region R is displayed on the TV monitor (not shown) by means of the drive unit (not shown) and observed by the operator.

Then, in changing the observational position of the rigid scope **602** from the observational dead-angle region R within a plane perpendicular to the direction of insertion of the insert portion **603**, the operator operates the rotation mechanism portion **626** to rotate the insert portion **603** in the direction of an arrow **627** shown in FIG. **55** with respect to the coupling portion **604**. As this is done, the rotation of the insert portion **603** is absorbed by the slack of the internal light guide **621** in the space portion **622**, so that the light guide **621** can never be pulled. Thus, the observational position of the rigid scope **602** can be changed without changing the respective positions of the coupling portion **604** and the grip portion **605** with respect to the operating microscope body **601**.

As the operator's treatment advances, it sometimes may be hindered by the coupling portion **604**, grip portion **605**, TV camera **606**, etc. during the observation of the observational dead-angle region R. In this case, the coupling portion **604** is rotated reversely in the direction of the arrow **627** with respect to the insert portion **603** by means of the rotation mechanism portion **626**. Thus, the respective positions of the grip portion **605**, coupling portion **604**, external light guide **607**, and TV camera **606** with respect to the operating microscope body **601** can be changed without changing the observational position of the rigid scope **602**.

According to the present embodiment, the grip portion **605** is located at the fixed distance L from the insert portion **603** with the coupling portion **604** between them. If the rigid scope **602** is inserted into the affected region (body cavity) under surgical microscopic observation, therefore, the microscope body **601**, grip portion **605**, and TV camera **606** can avoid interfering with each other. Since the external light guide **607** that is connected to the light source unit is guided in the same direction as the coupling portion **604**, moreover, it can be prevented from unexpectedly intercepting the microscopic field. Thus, the light guide **607** exerts no bad influence upon the microscopic observation.

Since the length of projection of the grip portion **605** and the TV camera **606** within the plane of the affected region is restricted to the minimum, e.g., the distance L, furthermore, the space required by the operator's surgical operation is reasonable, and the possibility of the projecting part hindering the operation can be minimized.

Further, the observational direction of the rigid scope **602** can be changed without changing the respective positions of the grip portion **605** and the TV camera **606**. When the observational direction of the rigid scope **602** is changed, therefore, the grip portion **605** and the TV camera **606** can be prevented from interfering with the operator's hands or body, and the external light guide **607** and the TV camera cable **618** can be prevented from intercepting the microscopic field. Thus, the efficiency of the surgical operation cannot be lowered. Since the respective positions of the grip portion **605** and the TV camera **606** can be changed without changing the observational position of the rigid scope **602**, moreover, change of a style can be quickly tackled with the progress of the operation, so that the efficiency of the operation is improved further.

Moreover, the upper surface **604***c* of the coupling portion **604** is coated with light absorbing paint such as matte black. If the coupling portion **604** gets into the surgical microscopic field, therefore, the illumination light of the operating microscope can be prevented from being reflected by the coupling portion **604** and dazzling in the microscopic field.

In connection with the present embodiment, furthermore, the coating method, e.g., matte black coating, has been described as reflection preventing means on the upper surface **604***c* of the coupling portion **604**. However, satin finish, filling, or other means for restraining reflection may be used with the same result.

With the arrangement in which the insert portion and the grip portion are coupled by means of the coupling portion so as to bend like a crank, as in the case of the sixteenth embodiment or the embodiments mentioned later, a plurality of rigid scopes **602** with different squint directions for the insert portion **603** may be prepared, or a joint structure may be provided such that a plurality of rigid scopes or insert portions with different squint directions can be attached and detached for replacement. According to the sixteenth embodiment, the squint direction is opposite to the direction of the coupling portion (and the direction of the mouthpiece for the external light guide **607**) against the grip portion. Alternatively, however, the direction of the coupling portion **604** or the mouthpiece for the external light guide **607** may be shifted around the axis of the insert portion. Rigid scopes of the conventional type may be available with various angular relations between the squint direction and the direction of the lateral mouthpiece for the external light guide.

Seventeenth Embodiment

A system according to a seventeenth embodiment will now be described with reference to FIGS. **56** to **58**. In the description of the present embodiment to follow, like reference numerals are used to designate the same portions of the sixteenth and seventeenth embodiments, and a description of those portions is omitted.

FIG. **56** shows a general configuration of a rigid scope system. The present embodiment is related mainly to an arm-type stand **630** for fixedly locating the rigid scope **602** in the operator's desired angular position.

The arm-type stand **630** for holding the rigid scope **602** comprises a first arm **631** that can be connected to the grip portion **605** of the rigid scope **602**. The first arm **631** is connected to a second arm **632** by means of a connecting portion **633** for rotation around axes O2 and O3. Likewise, the second arm **632** is connected to a third arm **634** by means of a connecting portion **635** for rotation around an axis O4, and the third arm **634** is connected to a stand holder **636** by means of a connecting portion **637** for rotation around an axis O5.

The axis O2 is the center line of the first arm **631** that extends at right angles to a reflected light axis O1' (mentioned later) of the rigid scope **602**, and the axis O3 extends at right angles to the axis O2. The axis O4 extends at right angles to the center line of the second arm **632**, while the axis O5 extends at right angles to the axis O4.

The third arm **634** is supported vertically on the stand holder **636** and connected thereto for up-and-down motion. The holder **636** can be attached integrally to a side rail of an operating table (not shown).

Each of the connecting portions **633**, **635** and **637** has an electromagnetic lock (brake, not shown) therein. The rotation around each of the axes O2 to O5 can be allowed by turning on an input switch (not shown) on the distal end of the first arm **631**, for example, and it can be prohibited by turning off the input switch.

All of the first to third arms **631**, **632** and **634** have a hollow structure. The cable **618** of the TV camera **606**, an arm light guide **638** (mentioned later), etc. are passed through the respective bores of these arms. The cable **618** and the guide **638** are exposed downward to the outside from the lower surface of the connecting portion **637**. The cable **618** and the arm light guide **638**, like the ones according to the sixteenth embodiment, can be connected to a drive unit and a light source unit (not shown).

The construction of the rigid scope **602** will now be described in detail with reference to FIG. **57**. In FIG. **57**, numeral **640** denotes a mirror that is fixed in the first bent portion **604***a* of the coupling portion **604**. The mirror **640** serves to bend a luminous flux, guided by the insert portion **603**, at about 90° to the longitudinal direction of the insert portion **603**. A relay optical system **641** is fixed in the coupling portion **604**. Located in the middle of the coupling portion **604** is a mirror **642**, which bends the luminous flux guided by the optical system **641** and guides it to the imaging lens **616**. The mirror **642** is fixed in the second bent portion **604***b* of the coupling portion **604** in a manner such that an extension of the reflected light axis O1' crosses the optical axis O1 of the relay optical system **611**, which is substantially in line with the central axis of the insert portion **603**, in the vicinity of the objective lens **609**. The reflected light axis O1' is substantially in line with the central axis of the grip portion **605**.

The insert portion **603** is provided with an internal light guide **643**, which, in conjunction with the illuminating lens **620**, constitutes an illumination optical system. One end of the guide **643** is connected optically to the lens **620**. The rear end portion of the guide **643** is led out in the same direction as the bending direction of the first bent portion **604***a* in a manner such that it is attached integrally to a light guide mouthpiece **644** on the rear end of the insert portion **603** by means of a sheathing **645**. A connecting portion **646** is provided on the other end of the internal light guide **643**. Further, the guide **643** can be fixed to the underside of the coupling portion **604** by means of hooks **647**.

A connecting portion **648** is provided on the rear end portion of the grip portion **605**. The connecting portion **648** engages a mounting portion **649** on the first arm **631** of the arm-type stand **630**, and is positioned by being fixed to the arm **631** by means of a so-called click mechanism that includes a groove portion **650** and a fixing ball **651**. Thus, the rigid scope **602** can be attached integrally to the stand **630**. The TV camera **606** can be also attached integrally to the first arm **631** of the stand **630** so that its image-pickup device **617** is located in the imaging position of the imaging lens **616**.

The connecting portion **648** of the grip portion **605** is provided with a bearing portion **652** that engages a flange **653**. The bearing portion **652** constitutes a rotation mechanism portion **654** for holding the coupling portion **604** for rotation around the axis O1'.

As mentioned before, moreover, the arm light guide **638** is incorporated in the arms that constitute the arm-type stand **630**. One end of the guide **638** is fixed by means of a light guide mouthpiece **656** at the distal end of the first arm **631**. The mouthpiece **656** has a mounting screw portion **657** that engages the connecting portion **646** to be connected optically to the internal light guide **643**.

As shown in FIG. **58**, the upper surface **604***c* of the coupling portion **604** has slopes **658** and **659** that are inclined at right angles to their longitudinal direction.

With this arrangement, the operator observes the observational dead-angle region R of the operating microscope by means of the rigid scope **602**, as in the case of the sixteenth embodiment. First, the operator holds the grip portion **605** of the rigid scope **602** and inserts the scope **602** into an affected region. Then, the operator, holding the grip portion **605**, turns on the input switch (not shown) on the first arm **631**. Thereupon, the electromagnetic locks in the connecting portions of the arm-type stand **630** are disengaged, so that the rotation around each of the axes O2 to O5 is allowed, and the rigid scope **602** can be operated freely. In this state, the objective lens **609** of the rigid scope **602** is located on the extension of the axis O1' that corresponds to the axis of the grip portion **605**. Accordingly, the operator can insert the insert portion **603** into the affected region and locate the objective lens **609** near the observational dead-angle region R with a feeling such that the rigid scope is a conventional rod-shaped scope without the coupling portion **604** and in a manner such that the grip portion **605** and the TV camera **606** are kept at the distance L from the microscope body **601**, as in the case of the sixteenth embodiment.

When the objective lens **609** is located in the observational dead-angle region R, the operator then turns off the input switch on the arm-type stand **630**. Thereupon, the respective electromagnetic locks of the connecting portions are fixed, and the rigid scope **602** is fixed with the objective lens **609** kept near the region R. If the coupling portion **604** then gets into the microscopic field of the microscope body **601**, as shown in FIG. **58**, the illumination light from the body **601** is reflected away from the microscopic field by the slopes **658** and **659** of the coupling portion **604**, as indicated by arrows W1 and W2 in FIG. **58**.

The illumination light emitted from the light source (not shown) is guided to the observational dead-angle region R by means of the arm light guide **638**, internal light guide **643**, and illuminating lens **620**. The light from the region R is transmitted through the objective lens **609**, prism **610**, and relay optical system **611**, and then bent at about 90° by means of the mirror **640**. After it is transmitted through the relay optical system **641**, moreover, the light is bent in the direction of the axis O1' by means of mirror **642**, and focused on the image-pickup device **617** of the TV camera **606** via the relay optical system **615** and the imaging lens **616**. A video image of the observational dead-angle region R is displayed on a TV monitor (not shown) by means of the drive unit (not shown) and observed by the operator.

Then, in changing the observational position of the rigid scope **602** from the observational dead-angle region R within a plane perpendicular to the direction of insertion of the insert portion **603**, the operator operates the rotation mechanism portion **654** to rotate the coupling portion **604** in the direction of an arrow **660** shown in FIG. **57** with respect to the grip portion **605**. As this is done, the internal light guide **643** is rotated integrally with the coupling portion **604** around the axis O1', since it is guided in the same direction as the bending direction of the first bent portion **604***a* and fixed integrally to the coupling portion **604** by means of the hooks **647**. Thus, the observational position of the rigid scope **602** can be changed without changing the respective positions of the grip portion **605**, TV camera **606**, and arm-type stand **630**.

If the operator's treatment is hindered by the grip portion **605**, coupling portion **604**, TV camera **606**, and arm-type stand **630** during the observation of the observational dead-angle region R as it advances, as in the case of the sixteenth embodiment, the grip portion **605** is rotated reversely in the direction of the arrow **660** with respect to the coupling portion **604** by means of the rotation mechanism portion **654**. Thus, the respective positions of the grip portion **605**, the TV camera **606**, and the arms that constitute the arm-type stand **630** with respect to the operating microscope body **601** can be changed without changing the observational position of the rigid scope **602**.

Depending on the conditions of the region to be observed, moreover, the operator must change the rigid scope **602** during a surgical operation. The rigid scope may be selected among ones of which the observational angle a of the objective lens **609** to the longitudinal direction of the insert portion **603** is different or the outside diameter of the insert portion **603** varies depending on the diameter of the opening of the body cavity to be penetrated thereby. In this case, the operator first loosens the mounting screw portion **657** to remove the connecting portion **646** of the internal light guide **643** from the light guide mouthpiece **656**. Further, the operator, holding the grip portion **605** in one hand and the first arm **631** in the other, pulls out the rigid scope **602** in the direction of an arrow **661** from the first arm **631**. Thereupon, the groove portion **650** of the connecting portion **648** is disengaged from the pin **651** of the first arm **631**, and the rigid scope **602** is removed from the first arm **631**.

Subsequently, a preferred rigid scope that is different from the one described above in the observational angle α and the outside diameter of the insert portion **603** is attached to the first arm **631**, reversely following the aforementioned steps of procedure, and is used in the same manner as aforesaid.

According to the present embodiment, the grip portion **605** is located at the fixed distance L from the insert portion **603** with the coupling portion **604** between them, as in the case of the sixteenth embodiment. Therefore, the surgical operation microscope body **601**, grip portion **605**, and TV camera **606** can avoid interfering with one another. Further, the length of projection of the grip portion **605** and the TV camera **606** within the plane of the affected region is restricted to the minimum or the distance L, and besides, the internal light guide **643** is guided in the same direction as the bending direction of the first bent portion **604***a* and fixed to the underside of the coupling portion **604**. Accordingly, the internal light guide **643** can be securely prevented from wrongly intercepting the microscopic field during the surgical operation.

Since the objective lens **609** of the rigid scope **602** is located on the axis of the grip portion **605**, moreover, the operator can adjust the observational position of the rigid scope with the same feeling of operation as that for a conventional rigid scope without the coupling portion **604**, and locate the objective lens **609** more quickly and securely in the target region. Since the cable **618** of the TV camera **606** and the light guides are incorporated in the holding arm for fixedly holding the rigid scope **602** itself, furthermore, the whole rigid scope system never unduly occupies the space for the operator's surgical operation, and the efficiency of the surgical operation can be prevented from lowering.

Since the observational direction of the rigid scope **602** can be changed by only rotating the coupling portion **604** with the length L, moreover, the grip portion **605** and the TV camera **606** can be prevented from interfering with the operator's hands or body when the observational direction is changed. Since the respective positions of the grip portion **605**, the TV camera **606**, and the arms of the arm-type stand **630** can be changed without changing the observational position of the rigid scope **602**, furthermore, change of the style can be quickly tackled with the progress of the operation, so that the efficiency of the operation is improved further.

Since the rigid scope **602** can be easily replaced with a new one during the surgical operation, moreover, an optimum rigid scope can be selected according to the progress of the operation, so that the efficiency of the operation is improved additionally.

Furthermore, the upper surface **604***c* of the coupling portion **604** is composed of the slopes **658** and **659**. If the coupling portion **604** gets into the field of the operating microscope, therefore, the illumination light of the operating microscope is reflected to the outside of the microscopic field and prevented from entering the field. Thus, the illumination light can be prevented from dazzling in the field of the operating microscope.

Eighteenth Embodiment

A system according to an eighteenth embodiment will now be described with reference to FIGS. **59** to **61**. In the description of the present embodiment to follow, like reference numerals are used to designate the same portions of the sixteenth to eighteenth embodiments, and a description of those portions is omitted.

FIG. **59** shows a general configuration of a rigid scope system. In FIG. **59**, numeral **670** denotes an arm-type stand for holding the rigid scope **602**. The stand **670** is obtained by modifying only the distal end portion of the first arm **631** of the arm-type stand **630** according to the seventeenth embodiment. More specifically, the TV camera **606** is held in a distal end portion **672** of a first arm **671**, and the cable **618** is housed in the arms **671**, **632** and **634** without being exposed to the outside. The grip portion **605** of the rigid scope **602** is provided with a control knob **673** for changing the observational direction.

The rigid scope **602** will now be described in detail with reference to FIG. **60**. An image guide **674**, formed of a light guide fiber, is fixedly incorporated in the coupling portion **604**. One end of the image guide **674** is connected optically to the relay optical system **611** in the insert portion **603** at the first bent portion **604***a*, while the other end of the guide **674** is connected optically to the relay optical system **615** in the grip portion **605** at the second bent portion **604***b*.

In the present embodiment, as in the seventeenth embodiment, the objective lens **609** is located in a position near the point of intersection of an extension of the optical axis O1' of the relay optical system **615**, which is substantially in line with the central axis of the grip portion **605**, and the optical axis O1 of the relay optical system **611**, which is substantially in line with the central axis of the insert portion **603**.

In FIG. **60**, numeral **675** denotes a light guide fixing portion, which serves to fix one end of the arm light guide **638** in the first arm **671**. A connecting light guide **676** is held in the grip portion **605** and the coupling portion **604**. One end of the light guide **676** is fixed in a connecting portion **677** of the grip portion **605** so as to be connected optically to the arm light guide **638**. The other end portion **678** of the connecting light guide **676** is circumferentially located so as to cover the outer periphery of the image guide **674** in the first bent portion **604***a*, and is fixed in the coupling portion **604** so as to be guided in the same direction as the bending direction of the first bent portion **604***a*.

In the insert portion **603**, on the other hand, an internal light guide **679**, which is connected optically to the illuminating lens **620**, is circumferentially located so as to cover the outer periphery of the relay optical system **611**. In the first bent portion **604***a*, the internal light guide **679** is circumferentially fixed so as to be connected optically to the connecting light guide **676**. The illuminating lens **620**, internal light guide **679**, and connecting light guide **676** constitutes an illumination optical system according to the present embodiment.

Provided in the grip portion **605**, moreover, is a cylindrical member **680** that is attached to the coupling portion **604** for rotation around a shaft **681**. The cylindrical member **680** is coupled with the observational direction changing control knob **673** on the grip portion **605**. As shown in FIG. **61**, a gear **682** is provided integrally on the outer periphery of the cylindrical member **680**.

In the coupling portion **604**, on the other hand, a gear **680** in mesh with the gear **682** is rotatably supported on a shaft **684**. In the first bent portion **604***a*, moreover, a gear **686** is provided in mesh with the gear **683**. The gear **686**, in conjunction with a bearing portion **687** in the housing of the coupling portion **604**, constitutes a rotation mechanism portion **688**.

With this arrangement, as in the cases of the sixteenth and seventeenth embodiments, the operator observes the observational dead-angle region R of the surgical microscope by means of the rigid scope **602**. First, the electromagnetic locks in the arm-type stand **670** are disengaged with the grip portion **605** of the rigid scope **602** held in position, the objective lens of the rigid scope **602** is moved to the observational dead-angle region R, and the electromagnetic locks of the stand **670** are worked again to hold and fix j rigid scope **602**. In this state, as in the case of the second embodiment, the objective lens **609** of the rigid scope **602** is located on the extension of the axis O1' that corresponds to the axis of the grip portion **605**. Accordingly, the operator can position the rigid scope **602** with a feeling such that the rigid scope is a conventional one without the coupling portion **604**.

Illumination light emitted from a light source (not shown) is guided to the observational dead-angle region R by means of the arm light guide **638**, connecting internal light guide **676**, and illuminating lens **620**. After the light from the region R is transmitted through the objective lens **609**, prism **610**, and relay optical system **611**, it is guided to the relay optical system **615** in the grip portion **605** by means of the image guide **674** in the coupling portion **604** and focused on the image-pickup device **617** of the TV camera **606**. Thereupon, a video image of the observational dead-angle region R is displayed on a TV monitor (not shown) by means of a drive unit (not shown) and observed by the operator.

Then, in changing the observational position of the rigid scope **602** from the region R, the operator turns the observational direction changing control knob **673** in the direction of an arrow **690**. As the knob **673** rotates, the gear **682** also rotates in the direction of the arrow **690** around the shaft **681**, so that the engaging gears **683** and **686** also rotate. Thereupon, the insert portion **603** is rotated in its central axis or the optical axis O1 by means of the rotation mechanism portion **688** that is composed of the gear **686** and the bearing portion **687**, whereby the observational direction of the objective lens **609** is changed. In this state, the internal light guide **679** and the connecting light guide **676** are circumferentially connected around the relay optical system **611** that has the optical axis O1. Accordingly, there is no possibility of the light guides being pulled or the illumination light suffering a loss as the insert portion **603** rotates. Thus, the illumination light is guided to the observational region, and the observational position of the rigid scope **602** is changed without changing the respective positions of the grip portion **605**, TV camera **606**, arm-type stand **670**, etc.

If the operator's treatment is hindered by the grip portion **605**, coupling portion **604**, TV camera **606**, and arm-type stand **670** during the observation of the observational dead-angle region R as it advances, the aforementioned processes of operation are carried out the other way around. The rotation mechanism portion **688** is operated by means of the observational direction changing control knob **673** to change the observational direction of the objective lens **609**. Thereafter, the arm-type stand **670** is operated to redirect the objective lens **609** to the observational dead-angle region R. Then, respective positions of the grip portion **605**, the TV camera **606**, and the arms that constitute the arm-type stand **670** are changed without moving the observational position of the rigid scope **602** from the region R.

In replacing the rigid scope **602** with one that is different in the observational angle and the outside diameter of the insert portion, as in the case of the seventeenth embodiment, the operator, holding the grip portion **605** in one hand and the first arm **671** in the other, pulls out the grip portion **605** of the rigid scope **602** in the direction of an arrow **691** from the first arm **671**. Thereupon, the groove portion **650** of the connecting portion is disengaged from the pin **651** in the distal end portion **672** of the first arm **671**, and the rigid scope **602** is removed from the arm-type stand **670**.

Then, the rigid scope that is different in the observational angle a and the outside diameter of the insert portion **603** is attached to the first arm **631**, reversely following the aforementioned steps of procedure. As this is done, the connecting light guide **676** is fixed in a position (position shown in FIG. **60**) where it is connected optically to the arm light guide **638** by means of the groove portion **650** and the pin **651**. The present embodiment has the following effects as well as the effects of the fifth embodiments. Since the cable **618** of the TV camera **606** and the light guides can be incorporated in the rigid scope **602** and the arm-type stand **670**, the whole rigid scope system never unduly occupies the space for the operator's surgical operation, and cables can be prevented from coiling around the operator's hands during the operation of the rigid scope **602**. Thus, the efficiency of the rigid scope **602** itself can be improved.

Further, the observational direction of the rigid scope **602** can be changed by operating the observational direction changing control knob **673** on the grip portion **605**. Thus, the observational direction can be easily changed one-handed according to the operation of the rigid scope **602**.

Since the light guides need not be attached or detached when the rigid scope is replaced during a surgical operation, the rigid scope can be changed more quickly, so that the efficiency of the surgical operation is enhanced.

According to the present embodiment, the gears are used as means for connecting the observational direction changing control knob **673** and the rotation mechanism portion **688**. It is to be understood, however, that the gears may be replaced with any other suitable motion transmitting mechanism, such as a wire belt or cam mechanism, with the same result.

The present invention is not limited to the embodiments described herein. According to the description of the foregoing embodiments, systems of the following particulars and optional combinations thereof can be obtained at the least.

In short, the rigid scope according to any of the sixteenth to eighteenth embodiments, having the observational optical system and the illumination optical system therein, comprises the insert portion, grip portion, and coupling portion that couples the insert and grip portions. The coupling portion includes the first and second bent portions, and the illumination optical system is guided in the same direction as the bending direction of the first bent portion.

This rigid scope is inserted into and fixed in the affected region under surgical microscopic observation without allowing its grip portion to interfere with the body of the operating microscope. Accordingly, the TV camera, cables, etc. can be securely prevented from interfering with the microscope body or intercepting the microscopic field.

The rigid scope may be provided with a rotation mechanism portion that can hold the insert portion and/or the grip portion for rotation with respect to the coupling portion.

In this case, the rigid scope can be inserted into and fixed in the affected region under surgical microscopic observation without having its grip portion interfere with the body of the operating microscope, and the position of observation by means of the rigid scope can be changed without changing the position of the rigid scope with respect to the operating microscope body. Therefore, the operator can set the observational position (or direction) in the affected region and the respective positions of the TV camera, light guides, holding arm, etc. in his or her desired relation. Further, the rigid scope can be located optimally depending on the location of the operating microscope and the operator's treatment style and method, changes during the surgical operation can be quickly tackled, and besides, the efficiency of the surgical operation can be enhanced considerably.

Moreover, a light guide that is connected to the illumination optical system may be detachably connected near the junction between the insert portion and the coupling portion.

Furthermore, a connecting portion to which the light guide connected to the illumination optical system is detachably connected may be provided in the vicinity of the grip portion.

Preferably, the respective central axes of the grip portion and the insert portion extend substantially parallel to each other.

Preferably, moreover, the objective lens should be fixed in the insert portion near an extension of the central axis of the grip portion.

The rotation mechanism portion should preferably be provided on the grip portion or the coupling portion.

An operating portion for operating the rotation mechanism portion should preferably be provided on the grip portion.

Reflection preventing means may be provided on the grip-portion-side surface of the coupling portion. Preferably, this preventing means is formed of a slope.

The following is a description of an endoscopic surgical system in an alternative form.

FIG. **72** shows the conventional endoscopic surgical system that includes a squint-type rigid scope **701**. This endoscopic surgical system comprises a TV camera system **702** formed of a TV camera head **702***a* and a controller **702***b*, monitor **703** for displaying an image picked up by means of the camera system **702**, light source unit **704** for supplying illumination light to the rigid scope **701**, and light guide **705**. During the surgical operation, the rigid scope **701** is fixedly supported by means of a scope holder **706**. The TV camera head **702***a* is connected to the rigid scope **701** in a manner such that the lower and upper parts of the display screen of the monitor **703** correspond to the deep side (distal end side) and the shallow side (hand side), respectively, with respect to the direction of insertion of the rigid scope **701**. An operator **700** operates an instrument **707** to perform extrac-

tion of a tumor, hemostasis, etc. while watching an endoscopic observational image on the monitor **703**.

Described in Jpn. Pat. Appln. KOKAI Publication No. 7-328015, for example, is a surgical manipulator that remotely operates the instrument under endoscopic observation in place of an operator. If the operator operates this surgical manipulator, a treatment manipulator is then actuated by means of an actuator, whereupon an affected region is treated. Further, the operator gets a display device on his or her head so that s/he can watch a display image thereon as s/he operates the manipulator to carry out a surgical operation. In this case, the operator's head is detected, and the observational position of the endoscope is moved correspondingly.

In FIG. **72**, the rigid scope **701** is used to observe a region on the left of the operator **700**, and a rigid scope image is displayed on the monitor **703**. If the operator moves the instrument **707** to the right (in the direction of arrow D**1**) on the monitor **703** while watching the image displayed on the monitor **703** in these conditions, the actual instrument **707** is moved forward or away from the operator (in the direction of arrow d**1**). If the operator **700** moves the instrument **707** to the left (in the direction of arrow B**1**) on the monitor **703**, on the other hand, the actual instrument **707** is moved toward the operator (in the direction of arrow b**1**).

In order to move the instrument **707** on the monitor **703** to the right or left (in the direction of arrow D**2** or B**2**) as the rigid scope in the state of FIG. **72** is turned counterclockwise for 90° to observe the operator side, as shown in FIG. **73**, the operator **700** is expected actually to move the instrument **707** in the opposite direction when compared to the image on the monitor **703**. Thus, in a surgical operation using an endoscope of which the observational direction is different from the direction of its insertion, the direction of actual movement of the instrument is not coincident with the moving direction of the instrument on the monitor. Accordingly, the operator must deliberate on the direction of the instrument to be moved while watching the monitor or confirm the moving direction by delicately moving the instrument to determine the direction in which the instrument is to be moved next. Therefore, the operation time is so long that the operator is fatigued inevitably. The operator can solve this problem by shifting his or her position relative to the affected region, depending on the observational direction of the endoscope, so that the operator's frontal direction is coincident with the observational direction. It is hard to attain this, however, since the instrument may interfere with a patient's body or some other surgical device.

On the other hand, the system described in Jpn. Pat. Appln. KOKAI Publication No. 7-328015 is designed to detect the operator's head in moving the endoscopic field. This system, however, is large-scaled and not easy to handle. In order to change the observational position of the endoscope, moreover, the operator's body or head must be moved. Therefore, this system is an effective measure for remote-controlled operation. Since the operating room is furnished with a lot of instruments and cables, however, the use of this system in the operating room is obstructive and narrows the range of the operator's movement. If the endoscope rotates around the course of insertion, moreover, the direction of the display image observed by the operator changes inevitably. Thus, the direction in which the master manipulator is to be moved is deviated from the direction in which the manipulator for treatment moves on the display image.

Accordingly, there is a demand for an endoscopic surgical system designed so that the manipulating direction of the instrument with respect to the operator's position is coincident with the moving direction of the instrument even if the observational direction of the endoscope is changed, whereby the operation time can be shortened, and the operator's fatigue can be eased.

FIGS. **62** to **71** show embodiments of endoscopic surgical systems that can fulfill these requirements.

The endoscopic surgical system shown in FIG. **62** comprises a rigid scope **801**, TV system **803** formed of a TV camera head **803***a* and a controller **803***b* attached to the hand-side portion the rigid scope **801**, and monitor **805**. An optical axis **813** of an objective lens **802** that is provided on the distal end of the rigid scope **801** is inclined at an angle a to a central axis O**1** of an insert portion **801***a* of the rigid scope **801**. An observational image that is obtained through the objective lens **802** is picked up by means of an image-pickup device (not shown) of the TV camera head **803***a* through the medium of a relay optical system and an imaging optical system (not shown). The TV camera head **803***a* causes the controller **803***b* to display the observational image on the monitor **805**. In FIG. **62**, numeral **806** denotes a light guide that is connected to a light source unit (not shown) for supplying illumination light to the field of the rigid scope **801**. The TV camera head **803** is connected to the rigid scope **801** in a manner such that the lower and upper parts of the display image of the monitor **805** correspond to the deep side (distal end side) and the shallow side (hand side), respectively, with respect to the direction of insertion of the rigid scope **801**.

In FIG. **62**, numeral **807** denotes a flexible scope holder for supporting the rigid scope **801**. It is fixed to a bedside stay (not shown). The scope holder **807** supports the rigid scope **801** for rocking motion around the central axis O**1**. In FIG. **62**, numeral **808** denotes an instrument **808**. The instrument **808** is fixed integrally to the insert portion **801***a* of the rigid scope **801** by means of a connecting member **812**. The instrument **808** includes an input portion **809** for the operator's manipulation and an output portion **810** that operates in response to the manipulation of the input portion **809**. Further, the instrument **808** is fitted with a bipolar probe **811** that is adapted to arrest bleeding or coagulate blood in an affected region when a high-frequency current is supplied across electrodes. The instrument **808** is connected to the rigid scope **801** in a positional relation such that the output portion **810** extends along the optical axis **813** of the scope **801** to ensure image-pickup operation by means of the scope **801** at all times.

FIGS. **63** and **64** show a specific configuration of the instrument **808**. As shown in FIG. **63**, the instrument **808** includes a lower chassis **808***a* connected integrally to the insert portion **801***a* of the rigid scope **801** by means of the connecting member **812**, upper chassis **808***b* rockably connected to the lower chassis **808***a*, and a joint **808***c* that connects the lower and upper chassis **808***a* and **808***b*. The upper chassis **808***b* can rock around an axis O**3** that extends substantially parallel to the central axis O**1** of the insert portion **801***a* of the rigid scope **801**.

The input portion **809** is provided with a hollow input lever **815**. The lever **815** includes a small-diameter grip portion **815***a* on the hand side (operator side) and a disk-shaped displacement portion **815***b* on the distal end side. The input lever **815** is formed having a narrow hole **815***c* and a recess **815***d* in the form of a spherical depression, located successively from the hand side in the order named. The bipolar probe **811** is inserted in the hole **815***c*. One end of a flexible tube **816**, which has an inside diameter equal to the

diameter of the hole **815***c*, is connected to the terminal end of the hole **815***c* (or the boundary between the hole **815***c* and the recess **815***d*). The bipolar probe **811** is inserted for axial movement in the tube **816**. One end of an upper support shaft **817** is fixed integrally to the upper chassis **808***b*. The other end of the shaft **817**, having a spherical shape, is fitted in the recess **815***d* of the input lever **815**, thereby supporting the distal end side of the lever **815** so that the lever **815** can tilt around its central portion T1. The upper support shaft **817** has a hollow structure that is penetrated by the tube **816**.

As is also shown in FIG. **64**, one end of each of four wires **820***a* to **820***d* is fixed to the displacement portion **815***b* of the input lever **815**. The wires **820***a* to **820***d* are fixedly arranged at angular spaces of **900** on the circumference of a circle with a radius r around the axis O4 that passes through the central portion T1. On the other hand, one end of each of four hollow flexible hoses **821***a* to **821***d* is connected to that part of the upper chassis **808***b* which faces the displacement portion **815***b*. The positions where the hoses **821***a* to **821***d* are connected correspond to the four positions where the wires **820***a* to **820***d* are fixed, respectively. The wires **820***a* to **820***d* are passed for axial movement in their corresponding hoses **821***a* to **821***d*.

The output portion **810** is provided with a hollow output lever **825**. The lever **825** includes a small-diameter portion **825***a* on the distal end side (affected region side) and a disk-shaped displacement portion **825***b* on the side farther from the affected region. The output lever **825** is formed having a narrow hole **825***c* and a recess **825***d* in the form of a spherical depression, located successively from the affected region side in the order named. The bipolar probe **811** is inserted in the hole **825***c*. The flexible tube **816**, which has the inside diameter equal to the diameter of the hole **825***c*, is connected to the terminal end of the hole **825***c* (or the boundary between the hole **825***c* and the recess **825***d*).

One end of a lower support shaft **827** is fixed integrally to the lower chassis **808***a*. The other end of the shaft **827**, having a spherical shape, is fitted in the recess **825***d* of the output lever **825**, thereby supporting the lever **825** so that the lever **825** can tilt around its central portion T2. The lower support shaft **827** has a hollow structure that is penetrated by the tube **816**.

The respective other ends of the four wires **820***a* to **820***d* are fixed to the displacement portion **825***b* of the output lever **825**. The wires **820***a* to **820***d* are fixedly arranged at angular spaces of **900** on the circumference of a circle with the radius r around an axis O4 that passes through the central portion T1. Further, the respective other ends of the hoses **821***a* to **821***d* are connected to that part of the lower chassis **808***a* which faces the displacement portion **825***b*. The positions where the other ends of the hoses **821***a* to **821***d* are connected correspond to the four positions where the wires **820***a* to **820***d* are fixed, respectively. As shown in FIG. **64**, in this case, the wires **820***a* to **820***d* and the hoses **821***a* to **821***d* are fixed to the displacement portion **825***b* and the lower chassis **808***a* in a manner such that the arrangement around the axis O4 on the side of the input portion **809** is rotated for 180° to realize the arrangement around the axis O5.

The following is a description of the operation of the endoscopic surgical system constructed in this manner.

When the rigid scope **801** is directed forward from the operator side, the observational image that is picked up by means of the scope **801** and the TV camera system **803** is displayed on the TV monitor **805**, as shown in FIG. **65**.

The bipolar probe **811** can be actually moved in the directions of arrows A3, B3, C3 and D3 on the screen of the monitor **805** by correspondingly tilting the input lever **815** in the directions of arrows a3, b3, c3 and d3. For example, the probe **811** can be moved to the right on the monitor **805** by tilting the lever **815** to the right. Thus, it is necessary only that the input lever **815** be tilted in a desired direction with reference to the image on the monitor **805**.

In moving the distal end of the bipolar probe **811** in the direction of arrow A3 (or upward) on the monitor **805**, for example, the input lever **815** is moved in the direction of arrow a3 (or upward). Thereupon, the lever **815** tilts around the central portion T1 with respect to the upper support shaft **817**, so that the wire **820***c* is pulled to the hand side, while the wire **820***a* is pushed out to the distal end side (or loosens). The pushed wire **820***a* advances in the hose **821***a*, thereby causing the output lever **825** to tilt in the direction of arrow a3 around the central portion T2. Thus, the distal end of the bipolar probe **811** moves in the direction of arrow A3 on the monitor **805**. For other directions, the system operates in the same manner. More specifically, if the input lever **815** is moved in the direction of arrow b3 (or to the left), the output lever **825** tilts in the direction of arrow b3, and the bipolar probe **811** moves in the direction of arrow B3 on the monitor **805**. If the input lever **815** is moved in the direction of arrow c3 (or downward), the output lever **825** tilts in the direction of arrow c3, and the probe **811** moves in the direction of arrow C3 on the monitor **805**. If the input lever **815** is moved in the direction of arrow d3 (or to the right), the output lever **825** tilts in the direction of arrow d3, and the probe **811** moves in the direction of arrow D3 on the monitor **805**. Moreover, the operator **700** can advance or retreat the bipolar probe **811** to a target region by moving it toward or away from the input lever **815**. As this is done, the probe **811** advances or retreats in the tube **816** so that it projects or recedes from the distal end of the output lever **825**.

The following is a description of the operation of the instrument **808** for the case where the rigid scope **801** is rotated counterclockwise for 90° around the axis O1 with respect to the operator **700** (case where the operator's left-hand side is observed, see FIG. **66**).

If the rigid scope **801** is rotated counterclockwise for 90°, as shown in FIG. **66**, the instrument **808** also rotates counterclockwise for 90° in one with the scope **801**. Since the position of the operator **700** relative to an affected region never changes during a surgical operation, however, the operator **700** can restore the input lever **815** to be operated to the position right in front of him or her by rotating the upper chassis **808***b* for 90° in the direction of arrow M with respect to the lower chassis **808***a*. Thus, the output lever **825** is deviated at 90° from the input lever **815**. Even in this case, however, the optical axis **813** of the rigid scope **801** and the output portion **810** of the instrument **808** are already moved integrally with each other, so that the relation shown in FIG. **65** is maintained between the moving direction of the output lever **825** of the instrument **808** on the monitor **805** and the manipulating direction of the input lever **815**. Thus, the output lever **825** or the bipolar probe **811** can be appropriately moved by tilting the input lever **815** in a desired direction to move the instrument **808** on the monitor **805**, only if the monitor **805** is located right in front of the operator **700** and if the input lever **815** of the instrument **808** is directed frontally (or toward the operator) as it is used.

According to the rigid scope system described above, change of the observational direction of the rigid scope **801** is transmitted mechanically to the instrument **808** to change the direction of the output with respect to the input with the scope **801** and the instrument **808** connected integrally with

each other. Therefore, the construction of the system is simple and never hinders surgical operations. Since the manipulation of the input portion **809** is transmitted to the output portion **810** by means of the flexible wires and hoses, moreover, the system can enjoy a simple configuration without requiring use of any complicated mechanisms.

According to the present embodiment, the instrument **808** is fixed integrally to the insert portion **801***a* of the rigid scope **801**. Alternatively, however, it may be fitted on the insert portion **801***a* of the rigid scope **801**, as in the case of the sheathing of a conventional endoscope, or may be formed having a bipolar probe or the like inserted therein, as in the case of the present embodiment.

FIG. **67** shows a modification. In this modification, the scope holder **807** is fixed mechanically to the upper chassis **808***b* by means of a rotation regulating member **830**. According to this arrangement, the input portion **809** never fails to be situated right in front of the operator if the rigid scope **801** is rotated around the axis O1. Thus, the operation time can be shortened.

FIGS. **68** to **70** show another embodiment. In the description of the present embodiment to follow, like reference numerals are used to designate those components which are common to the present embodiment and the embodiment shown in FIGS. **62** to **67**, and a description of those portions is omitted.

As shown in FIG. **68**, an endoscopic surgical system according to the present embodiment comprises a scope holder **840** that supports the rigid scope **801** for sliding motion in X-, Y-, and Z-axis directions. The holder **840** is fixed to a bedside stay **841***a*. The holder **840** includes a rigid scope connecting member **842**. The connecting member **842** is provided with angle detecting means **843** for detecting the rotational angle of the rigid scope **801** compared to the scope holder **840**. The detecting means **843**, which is formed of an encoder **844** (see FIG. **70**), serves to detect the rotational angle of the insert portion **801***a* of the scope **801** around the central axis O1.

Further, this endoscopic surgical system comprises an instrument holder **845** that holds the instrument **808** for sliding motion in the X-, Y-, and Z-axis directions. The holder **845**, which is fixed to a bedside stay **841***b*, includes an instrument connecting member **846** for supporting the instrument **808**.

As shown in FIG. **69**, the instrument connecting member **846** on the distal end portion of the instrument holder **845** includes a gear **847** that is fixed to the lower chassis **808***a* of the instrument **808** in a nonrotatable manner. The gear **847**, along with the connecting member **846**, restrains the lower chassis **808***a* from moving along the axis O3 and holds it for rocking motion around the axis O3 at the joint **808***c*. On the other hand, the upper chassis **808***b* is restrained from rocking around the axis O3 by means of a pin **852** that is attached to the connecting member **846**.

The instrument connecting member **846** is provided with a motor **848** that is fixed to a holding member **899**. A gear **849** in mesh with the gear **847** is fixed coaxially to an output shaft **848***a* of the motor **848**. The input and output portions **809** and **810** of the instrument **808** and the mechanism for transmitting their motions are constructed in the same manner as the ones according to the first embodiment.

As shown in FIG. **70**, the encoder **844** that constitutes the angle detecting means **843** is connected to a control circuit **850**. The circuit **850** is connected to a motor driver circuit **851** that is connected to the motor **848**. In response to an input signal from the encoder **844**, the control circuit **850** delivers a given signal to the driver circuit **851** according to predetermined conditions, in order to rock the instrument **808** around the axis O3 in the same direction and at the same angle as the rotation of the rigid scope **801** around the central axis O1.

The following is a description of the operation of the endoscopic surgical system constructed in this manner.

If the rigid scope **801** is rotated around the axis O1, the rotational angle of the rigid scope **801** compared to the rigid scope connecting member **842** is detected by means of the encoder **844** of the angle detecting means **843**, and angle information is delivered to the control circuit **850**. Based on this angle information, the control circuit **850** computes the rotational angle of the rigid scope **801**, and delivers a signal to the motor driver circuit **851** to rotate the instrument **808** for the same angle. In response to this input signal, the driver circuit **851** causes the motor **848** to rotate for a required amount. The rotation of the motor **848** is transmitted to the lower chassis **808***a* with the gear **847** in mesh with the gear **849** that is fixed coaxially to the output shaft **848***a*, whereupon the chassis **808***a* rotates for the same angle as the rigid scope **801**. Thus, the observational direction of the scope **801** and the direction of the output portion **810** of the instrument **808** have the same relation as in the embodiment shown in FIGS. **62** to **67**. In this state, the upper chassis **808***b* is prevented from rotating with respective to the instrument connecting member **846** by the agency of the pin **852**. Therefore, the position of the input portion **809** compared to the operator **700** never changes. Accordingly, the direction of the operator's manipulation of the instrument **808** can be made to coincide with the moving direction of the instrument **808** on the monitor **805**. If the output portion **810** of the instrument **808** is deviated from the range of observation as the rigid scope **801** rotates around the central axis O1, the instrument **808** is moved in the X-, Y-, and Z-axis directions for adjustment by means of the instrument holder **845**.

As described above, the present embodiment, unlike the embodiment shown in FIGS. **62** to **67**, is designed so that the rotation of the rigid scope **801** around the direction of insertion is detected electrically, and the output portion **810** of the instrument **808** is rotated electrically. Therefore, the scope **801** and the instrument **808** can be held separately from each other, so that they can be inserted from different directions into different positions, depending on the conditions of the surgical operation. Thus, the system of the present embodiment can cope with a wide variety of styles of surgical operations.

According to the present embodiment, moreover, the rotation of the rigid scope **801** is detected by means of the encoder **844**. Alternatively, however, it may be detected by means of conventional optical position detecting means, which is designed so that an illuminant is connected to the rigid scope **801**, its image is picked up by means of image-pickup means (TV camera), and the position and rotational angle of the rigid scope are computed in accordance with the resulting image-pickup signal. Thus, the position detection can be effected even without the use of any scope holder.

FIG. **71** shows still another embodiment. The rigid scope **801**, TV camera system **803**, monitor **805**, scope holder **840**, and rotational angle detecting means for detecting the position of the rigid scope **801** with respect to the holder **840**, according to the present embodiment, are constructed in the same manner as the ones according to the foregoing embodiment, so that a description of those components is omitted. The following is a description of an instrument **863**, a component of an alternative construction, only.

In FIG. **71**, numeral **860** denotes a slave manipulator (hereinafter referred to as treatment manipulator) that has the instrument **863** fixed on its distal end and is attached to the bedside stay **841***b*. The treatment manipulator **860** is composed of a first operating arm **860***a* for use as a support mechanism movable in the vertical direction and turning direction, a second operating arm **860***b* attached to the first arm **860***a* and movable in the horizontal direction, and a joint portion **860***c* attached to the distal end portion of the second arm **860***b*. Further, the treatment manipulator **860** is connected, by means of a manipulator control device **861** and a direction changing circuit **865**, to a master manipulator **862** in a region that is accessible to the operator.

As is generally known, the manipulator control device **861** receives a signal from the master manipulator **862** and delivers a driving signal to the treatment manipulator **860** such that the manipulator **860** moves in the same manner as the manipulator **862** does.

The direction changing circuit **865** is connected with an encoder **844** that constitutes the same angle detecting means **843** as aforesaid. On receiving an input signal from the encoder **844**, the circuit **865** changes a signal from the manipulator control device **861** according to a given transformation formula, and delivers a driving signal for changing the operating direction of the treatment manipulator **860**, compared to the manipulation of the master manipulator **862**, to the manipulator **860**.

The first and second operating arms **860***a* and **860***b* of the treatment manipulator **860** have the drive structure of a manipulator of a so-called cylindrical-coordinate type, formed of vertical, turning, and horizontal operation axes e, f and g that are activated by means of actuators (not shown), such as electromagnetic motors. Alternatively, however, the operating arms may have the structure of a so-called multi-joint manipulator formed of a plurality of joint portions. The joint portion **860***c* is connected to the instrument **863** so that it can be actuated by means of an actuator, such as an electromagnetic motor, to tilt the instrument **863** around two axes h and i that extend at right angles to each other.

The following is a description of the operation of the endoscopic surgical system constructed in this manner.

A distal end position Q of the instrument **863** that is connected to the treatment manipulator **860** is known by means of the manipulator control device **861**, based on the respective operating positions of the vertical, turning, horizontal, and tilting axes e, f, g, h and i and the geometric dimensions of the individual members. On the other hand, the position of a point of action **862***a* of the master manipulator **862** is obtained by computation by means of the manipulator control device **861**. A signal is delivered from the control device **861** to the direction changing circuit **865** such that the instrument distal end Q moves to the position of the point of action **862***a* of the master manipulator **862**. As in the case of the foregoing embodiment, moreover, the observational direction of the rigid scope **801** is detected by means of the encoder **844** of the angle detecting means **843** and transmitted to the direction changing circuit **865**.

Based on the signal from the encoder **844**, the direction changing circuit **865** computes the input signal from the manipulator control device **861** according to a previously stored computational formula, and delivers a driving signal to the treatment manipulator **860** such that the manipulating direction of the master manipulator **862** is always coincident with the moving direction of the instrument **863** on the monitor **805**. Thus, the signal is delivered to the treatment manipulator **860** so that the moving direction of the distal end position Q of the instrument **863** displayed on the screen of the monitor **805** is coincident with the manipulating direction of the master manipulator **862**, as in the case of the foregoing embodiment. Thereupon, the direction of the operator's manipulation of the instrument **863** is coincident with the moving direction of the instrument **863** on the monitor **805**.

According to the present embodiment, as described above, the instrument **863** can be remotely manipulated by means of the master manipulator **862**, so that the operator can carry out a surgical operation in any convenient position without restrictions on the location of the manipulator **862**. Thus, the operator can perform the operation in a more comfortable posture.

In short, the endoscopic surgical systems described with reference to FIGS. **62** to **71** comprises an endoscope capable of observation in directions different from the direction of its insertion; image-pickup means connected to the endoscope and capable of picking up an observational image of the endoscope; display means for displaying information from the image-pickup means; an instrument including an input portion for an operator's manipulation, an output portion adapted to operate in response to the manipulation of the input portion, and operating direction changing means capable of changing the operating direction of the output portion with respect to the input portion; and control means adapted to operate the operating direction changing means as the direction of observation around the direction of insertion of the endoscope changes.

In this system, the control means drives the operating direction changing means to control the operating direction of the output portion of the instrument with respect to the direction of manipulation of the input portion, in response to vertical and horizontal shifts of an affected region on the display means caused when the endoscope rotates around the direction of insertion. The operating direction of the output portion of the instrument on the display means is controlled so that it is always coincident with the direction of actual manipulation of the input portion of the instrument. Thus, if the operator manipulates the input portion of the instrument in the same direction as the direction in which the output portion of the instrument is expected to move, while watching the display means, the output portion moves in the intended or expected direction on the display means. Accordingly, the moving direction need not be considered or confirmed during the surgical operation. In consequence, the manipulation of the instrument is easy, the operation time is shortened, and therefore, the operator's fatigue can be eased.

Preferably, the operating direction changing means includes manipulation transmitting means for transmitting the manipulation of the input portion to the output portion and a rotating portion capable of rotating the output portion around the direction of insertion of the instrument into the affected region, with respect to the input portion, and the control means includes rotation transmitting means for transmitting the rotation around the direction of insertion of the endoscope, thereby rotating the rotating portion. When the endoscope rotates around the direction of insertion, in this case, the rotation transmitting means rotates the rotating portion of the instrument. Thereupon, the output portion rotates around the direction of insertion with respect to the input portion of the instrument. In this state, the manipulation transmitting means transmits the manipulation of the input portion to the output portion, so that the operating direction of the output portion is changed with respect to the input operation.

The manipulation transmitting means may be mechanical transmitting means.

In the case where the rotation transmitting means is provided with a connecting member for connecting the endoscope and the instrument integrally to each other, the connecting member causes the instrument to rotate integrally with the rigid scope so that the rotating portion of the instrument rotates when the endoscope rotates around the direction of insertion. Thereupon, the output portion rotates in the direction of insertion with respect to the input portion of the instrument. In this state, the manipulation transmitting means transmits the manipulation of the input portion to the output portion, so that the operating direction of the output portion is changed with respect to the input operation.

Preferably, the rotation transmitting means includes rotation detecting means for detecting the rotational displacement of the endoscope in the direction of insertion with respect to a given region, drive means capable of rotating the rotating portion, and electrical control means for controlling the drive of the drive means in accordance with a signal from the rotation detecting means. In this case, the rotation of the endoscope around the direction of insertion is detected by the rotation detecting means and applied to the electrical control means. Based on this input signal, the electrical control means drives the drive means to rotate the rotating portion. Thereupon, the output portion rotates in the direction of insertion with respect to the input portion of the instrument. In this state, the manipulation transmitting means transmits the manipulation of the input portion to the output portion, so that the operating direction of the output portion is changed with respect to the input operation.

The rotation detecting means may be an encoder.

Preferably, moreover, the rotation detecting means is provided with an optical illuminant, second image-pickup means for picking up an image of the optical illuminant, and optical position detecting means including computing means for computing the rotational angle of the endoscope in accordance with a signal from the second image-pickup means.

The drive means may be a motor.

The mechanical transmitting means may be provided with a first flexible member and a second flexible member capable of being displaced relatively to the first flexible member. Preferably, the first flexible member is a wire, and the second flexible member is a hose fitted on the wire.

Further, there may be provided an endoscopic surgical system comprising an endoscope capable of lateral observation; image-pickup means connected to the endoscope and capable of picking up an observational image of the endoscope; display means for displaying information from the image-pickup means; an instrument including a master manipulator for an operator's manipulation, a slave manipulator adapted to operate in response to the manipulation, and manipulator control means for controlling the slave manipulator so that the slave manipulator operates following the master manipulator; rotation detecting means for detecting the rotational displacement of the endoscope around the direction of insertion, and manipulator operating direction changing means for controlling the operating direction of the slave manipulator in accordance with information from the manipulator control means and the rotation detecting means.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

What is claimed is:

1. A surgical observational system comprising:

an observational optical system which forms an optical image of an object including an affected region;

first observational means for observing the optical image;

second observational means which obtains an image showing a desired area of the object found in the optical image, the second observational means being different from the first observational means at least in terms of an observational direction or observational method;

display means for displaying the image showing the desired area obtained by the second observational means;

means for optically transmitting the image showing the desired area displayed by the display means to the observation optical system so that the image showing the desired area is superposed on the optical image of the object observed by the first observation means;

detecting means which detects a relative position of the first and second observational means in three dimensions; and

means for controlling a display position of the image showing the desired area displayed on the display means in accordance with the detected relative position of the first and second observational means in three dimensions to superpose the image showing the desired area displayed on the display means on the desired area of the optical image.

2. The surgical observational system according to claim **1**, wherein the second observational means comprises one of an endoscope, rigid scope and ultrasonic diagnostic apparatus.

3. A surgical observational system comprising:

an observational optical system for forming an optical image of an object including an affected region,

first observational means for observing the optical image;

an indicator indicative of a desired position in the optical image;

second observational means which obtains an image including the desired position indicated by the indicator, the second observational means being different from the first observational means at least in terms of an observational direction or observational method;

display means for displaying the image including the desired position indicated by the indicator;

means for optically transmitting the image including the desired position displayed on the display means to the observational optical system so that the image including the desired position is superposed on the optical image of the object observed by the first observational means;

detecting means which detects a relative position of the first and second observational means in three dimensions; and

means for controlling a display position of the image including the desired position displayed on the display means in accordance with the detected relative position of the first and second observational means in three dimensions so that the image including the desired position is superposed on the desired position of the optical image.

4. The surgical observational system according to claim 3, wherein the indicator is provided at a predetermined position of the second observational means.

5. The surgical observational system according to claim 3, wherein the second observational means comprises one of an endoscope, rigid scope and ultrasonic diagnostic apparatus.

6. The surgical observational system according to claim 5 wherein the second observational means comprises an ultrasonic diagnostic apparatus, and the indicator comprises a distal end portion of a probe of the ultrasonic diagnostic apparatus.

7. The surgical observational system according to claim further comprising:

setting means for setting a size of the image which is obtained by the second observational means, and is superposed on the desired position of the optical image, in accordance with a magnification of the optical image observed by the first observational means.

8. The surgical observational system according to claim 3, wherein the indicator comprises a cursor displayed on the optical image observed by the first observational means.

9. A surgical observational system comprising:

a first observational apparatus including a first optical system which forms an optical image of an object;

a second observational apparatus different from the first observational apparatus at least in terms of an observational direction or observational method, the second observational apparatus including an elongated member that is capable of obtaining an image showing a desired area of the object found in the optical image;

a monitor provided for the first observational apparatus that is capable of displaying the image showing the desired area obtained by the second observational apparatus;

a second optical system provided for the first observational apparatus that optically transmits the image showing the desired area to the first optical system so that the image showing the desired area obtained by the second observational apparatus is superposed on the optical image observed by the first observational apparatus;

a detector which detects a relative position of the first and second observational apparatuses in three dimensions; and

a computer that is electrically connected to the monitor and to the detector, and that is capable of controlling a display position of the image showing the desired area on the monitor in accordance with a detection result of the detector such that the image showing the desired area obtained by the second observational apparatus is superposed on the desired area of the optical image observed by the first observational apparatus.

10. The surgical observational system according to claim 9, wherein the second observational apparatus comprises one of an endoscope, rigid scope and ultrasonic diagnostic apparatus.

11. The surgical observational system according to claim 9, wherein the computer sets a size of the image showing the desired area superposed on the desired area of the optical image and displayed on the monitor in accordance with a magnification of the optical image observed by the first observational apparatus.

12. A surgical observational system comprising:

a first observational apparatus including a first optical system which forms an optical image of an object;

an indicator indicative of a desired position in the optical image;

a second observational apparatus different from the first observational apparatus at least in terms of an observational direction or observational method, the second observational apparatus including an elongated member that is capable of obtaining an image including the desired position indicated by the indicator;

a monitor provided for the first observational apparatus that is capable of displaying the image showing the desired area obtained by the second observational apparatus;

a second optical system provided for the first observational apparatus that optically transmits the image including the desired position to the first optical system so that the image including the desired position obtained by the second observational apparatus is superposed on the optical image observed by the first observational system;

a detector which detects a relative position of the first and second observational apparatuses in three dimensions; and

a computer that is electrically connected to the monitor and to the detector, and that is capable of controlling a display position of the image including the desired position displayed on the monitor in accordance with a detection result of the detector such that the image including the desired position obtained by the second observational apparatus is superposed on the desired position of the optical image observed by the first observational apparatus.

13. The surgical observational system according to claim 12, wherein the indicator is provided at a predetermined position of the second observational apparatus.

14. The surgical observational system according to claim 12, wherein the second observational apparatus comprises one of an endoscope, rigid scope and ultrasonic diagnostic apparatus.

15. The surgical observational system according to claim 12, wherein the second observational apparatus comprises an ultrasonic diagnostic apparatus, and the indicator comprises a distal end portion of a probe of the ultrasonic diagnostic apparatus.

16. The surgical observational system according to claim 19, wherein the computer also sets a size of the image including the desired position superposed on the desired position of the optical image and displayed on the monitor in accordance with a magnification of the optical image observed by the first observational apparatus.

17. The surgical observational system according to claim 12, wherein the indicator comprises a cursor displayed on the optical image observed by the first observational means.

18. A surgical observational system comprising:

a first observation apparatus for observing a first image of an object;

a second observation apparatus which obtains a second image which is an image showing a desired area of the object found in the first image, the second observational means being different from the first observational apparatus at least in terms of an observation direction or observational method;

a monitor provided for the first observational apparatus that is capable of displaying the second image obtained by the second observational apparatus;

an optical system provided for the first observational apparatus that optically transmits the second image

displayed on the monitor so that the second image is superposed on the first image observed by the first observational apparatus;

a detector which detects a relative position of the first and second observational apparatuses in three dimensions; and

a computer that is electrically connected to the monitor and to the detector, and that is capable of controlling a display position of the second image displayed on the monitor in accordance with the detected relative position of the first and second observational apparatus in three dimensions to superpose the second image on the desired area of the first image.

19. A surgical observational system comprising:

a first observational apparatus for observing a first image of an object;

an indicator indicative of a desired position in the first image;

a second observational apparatus which obtains a second image which is an image including the desired position indicated by the indicator and found in the first image, the second observational apparatus being different from the first observational apparatus at least in terms of an observational direction or observational method;

a monitor provided for the first observational apparatus that displays the second image obtained by the second observational apparatus;

an optical system provided for the first observational apparatus that optically transmits the second image displayed on the monitor so that the second image is superposed on the first image observed by the first observational apparatus;

a detector which detects a relative position of the first and second observational apparatuses in three dimensions; and

a computer that is electrically connected to the monitor and to the detector, and that is capable of controlling a display position of the second image displayed on the monitor in accordance with the detected relative position of the first and second observational apparatus in three dimensions to superpose the second image on the desired area of the first image.

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